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Institute of Food Technologists

THE PROFESSIONAL SOCIETY OF FOOD TECHNOLOGISTS

The Institute of Food Technologists numbers among its active members leading scientists, technologists and engineers in the field of Food Technology.

The Institute invites your professional association with this select group of scientific and technological workers. Only those who are qualified by education, special training, or experience are extended this invitation.

Food Technology may be defined as the application of science and engineering to the production, processing, packaging, distribution, preparation and utilization of foods. Scientists, technologists and engineers engaged in Food Technology, executives, officials and supervisors under whose jurisdiction Food Technology operations are conducted, research investigators, teachers, and others working in the field of Food Technology, will find membership in the Institute worth many times its modest cost.

If you can meet the qualifications for membership, you owe it to yourself and to your business or profession to become a member.

OBJECTIVES

The Institute is a non-profit, professional, educational association to promote the application of science and engineering to the production, processing, packaging, distribution, preparation, and utilization of foods; it stimulates investigations into technological problems arising therein, it provides a medium for presenting and discussing the results of such investigations; it stimulates and provides means for the free interchange of technological information and ideas among food technologists; it promotes recognition of the role of food technologists in the technical direction of operations in these fields; all of these activities have the ultimate objective of providing better and adequate foods for mankind.

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Organized July 1, 1939, at Cambridge, Mass., with a membership of less than 100, the Institute has grown to more than 3,500 (1951). It is world-wide in scope, with members in North, Central, and South Americas, the Scandinavian countries, England, Holland, Germany, France, India, Australia, and New Zealand.

MEMBERSHIPS

Professional Members. Any person who is ethically qualified, and who has had training and experience in food technology, or any person who in the opinion of the Council is recognized as distinguished in the contributing sciences as they apply to foods, shall be eligible to be a Professional Member of the Institute. The minimum training which shall qualify a candidate for eligibility for Professional Member is, in general, graduation from a college, university, or similar institution in which he has majored in one or more of the sciences or branches of engineering associated with food technology. The minimum experience shall be three years experience in food technology. The Council may, at its discretion, waive any or all of the foregoing requirements in the case of a person who, thru long experience, has distinguished himself in the field of food technology.

Members. Any ethically qualified person, active in special or limited aspects of food technology, who is an administrator, director or executive under whose jurisdiction operations in food technology are conducted; or who is engaged in the dissemination of knowledge of food technology; or one whose work requires a general knowledge of the broad principles of food technology as it applies to the products, processes or equipment with which he or she is concerned; or one scientifically trained in and who has entered a career in food technology; shall be eligible to become a Member.

Student Members. Any ethically qualified person who has never been a Professional Member or Member of the Institute, who is registered as a student in an educational institution with at least Junior (third year) standing, who is a candidate for a Bachelor's or higher degree in one or more of the sciences or branches of engineering associated with food technology, shall be eligible for membership as a Student Member. This classification shall be his status only until the end of the calendar year in which he completes his schooling. When graduated and otherwise qualified as defined in the section on "Members," a Student Member may, upon application, be elected to Membership.

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FOOD TECHNOLOGY, issued monthly, is the official journal of the Institute. It is published to advance the profession of food technology by disseminating the results of research and their practical application in industry. Contributors to its pages represent many fields of scientific and technological interest.

FOOD RESEARCH, published bi-monthly, is devoted to publication of the results of original investigations and occasional reviews in the fields of food and beverage technology, chemistry, and microbiology. FOOD RESEARCH is available to Institute members at the special rate of $4.50 per year.

REGIONAL SECTIONS

Where sufficient members (25 or more) live within commuting distance of a given point, a Regional Section may be established. Such Sections are able to hold meetings at more frequent intervals than the National group, thus affording the food technologists regular opportunities for an exchange of views and ideas with others in the area. There are presently 21 Regional Sections.

ANNUAL MEETINGS

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AWARDS

The society administers the following awards:

NICHOLAS APPERT AWARD (Medal). Each year the Chicago Section of the Institute makes this award to a person whose contributions to the food industry make him distinguished and outstanding in the opinion of the national jury.

STEPHEN M. BABCOCK AWARD ($1,000.00). The purpose of this award, made by the Nutrition Foundation, is to encourage contributions to FOOD TECHNOLOGY which will have an influence on the nutritional well-being of the general population.

FOOD ENGINEERING ACHIEVEMENT AWARD Plaque). Presented bi-annually to the food company which has made the greatest achievement in food technology during the previous two years. The purpose of this award—presented by FOOD ENGINEERING magazine—is to stimulate progress in the industrial application of food technology by food companies, and to encourage the cooperative teamwork between research and production that is the indispensable basis of industrial progress.

FUTURE ANNUAL CONFERENCES

1952 Grand Rapids, Mich.
1953 Boston, Mass.
1954 Los Angeles, Calif.
1955 Columbus, Calif.

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Effect of Antioxidant on Rancidity Development in Frozen Creamed Turkey [a]

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(Manuscript received August 21, 1951)

The well-recognized instability of turkey fat has been an adverse factor in the preparation of frozen creamed turkey. It can be counteracted readily with appropriate concentrations of commercial antioxidants, which are added preferably while the meat is being cooked.

Utilization of turkeys in precooked frozen foods has been limited by the susceptibility of turkey fat to development of rancidity. The relative instability of turkey fat compared to chicken fat is generally recognized throughout the industry. This difference in stability was specifically demonstrated recently for precooked frozen creamed chicken and turkey *(1)*. In that study peroxide values were higher and off-flavor (rancidity) scores were greater in the creamed turkey than in the creamed chicken, particularly when the white sauce was made with turkey fat instead of a hydrogenated shortening. The study also revealed that the fat recovered from the turkey cooking liquid had rather high peroxide values.

This observation led to tests of the value of adding antioxidants to the water in which the turkey was cooked. The experiments reported here show that a commercially formulated antioxidant decreases rancidity development during cooking and frozen storage of creamed turkey. As expected, it also retards rancidity development if added to the creamed turkey ingredients (after cooking) rather than to the cooking liquid. The antioxidant appears to be stable under the cooking conditions used, which differ markedly from deep-fat-frying conditions that Sair and Hall *(3)* found were destructive to antioxidants. The formulated antioxidant used was Tenox II, which is composed of 20% butylated hydroxyanisole, 6% propyl gallate, 4% citric acid, and 70% propylene glycol. Sustane 3 is a similar type of mixture.

Limited tests with other antioxidants are reported also. These include nordihydroguaiaretic acid (NDGA), propyl gallate, and butylated hydroxyanisole.

METHODS

The following procedures were used in experiments with Tenox II. Frozen turkeys were sawed in quarters and thawed overnight at room temperature (70° F., 21° C.). Half birds were cooked by simmering in covered stainless-steel kettles with 1 liter of water per 2,270 g. of turkey. The antioxidant was added to the cooking water before cooking. The amount of antioxidant added was 0.005% of the uncooked weight of the turkey halves. The other half of each turkey was cooked without added antioxidant. A peroxide test was made on the fat immediately after cooking. The cooked turkey was boned and diced by hand. The broth and fat were separated for use in preparing the white sauce. The proportion of ingredients for the sauce was as follows: liquid, 89.1-90.2%; fat, 4.6%; flour 4.6-5.7%; and salt, 0.6%.

The melted fat and flour were combined in a steam-jacketed kettle and stirred to a smooth paste. The liquid, heated to 140° F. (60° C.), was added and the mixture was heated, with constant stirring, to 194° F. (90° C.). With steam pressure at 5 lbs., the sauce was then cooked with constant stirring for 5 minutes. Salt was added at the end of the cooking period. When the antioxidant was added to the sauce instead of during cooking, enough was added to the melted fat so that the final concentration in the creamed turkey would be the same as that resulting from the addition of antioxidant during cooking. The sauce and diced turkey meat were combined in a ratio of approximately 44% meat and 56% sauce, canned or otherwise packaged, and frozen in an air blast at —10° F. (—23° C.). The products were then transferred for storage at other temperatures. The experiments varied in the type of liquid and fat used in the sauce and in the type of container as follows:

Experiment No.	Type of liquid in sauce	Type of fat in sauce	Type of container
1a	Turkey broth	Hydrogenated vegetable oil	Plain tin can
1b	Skim milk	Hydrogenated vegetable oil	Plain tin can
2	Turkey broth	Turkey fat	Plain tin can
3	Skim milk	Turkey fat	MSAT cellophane bag, locker carton, sealed waxed paper overwrap
5a	Broth plus skim milk, 3:1	Turkey fat	MSAT cellophane bag, locker carton, sealed waxed paper overwrap
5b	Broth plus skim milk, 3:1	Turkey fat	Visqueen bags, parchment overwrap

The initial determinations of flavor differences and of peroxide value of the fat of the creamed turkey were begun as soon as the samples were frozen. Other analyses were made after the products were stored for 4 to 12 months.

The frozen products were thawed at room temperature and heated on a steam bath for 30 minutes. The heated creamed turkey was presented to a panel of 7 judges for evaluating "rancid off-flavor" and "other off-flavor". Scoring was based on a scale of 0 to 10 points, with a score of 0 indicating no off-flavor and a score of 10 indicating extreme off-flavor. Since only the score for "rancid off-flavor" showed differences, the results of scoring "other off-flavor" are not reported. At all storage periods, each sample was judged either 4 or 5 times by each judge according to a randomized block design (in which 3 or 4 treatments were judged at a time) or according to a balanced incomplete block design (in which 4 of the 5 treatments were judged at a time). Statistical significance of the differences in scores was determined by analysis of variance of daily panel means or individual judge's means.

Peroxide values of the crude fat extracted from the creamed turkey (meat plus cream sauce) were determined by a modification of Wheeler's method *(2)*. The fat was extracted by disintegrating in a blender the contents of one package (166 g.) with 200 ml. of chloroform and about 30 g. of anhydrous sodium sulfate. After filtration, the chloroform layer was separated from

[a] Presented at the Eleventh Annual Meeting of the IFT, New York, N. Y., June 19, 1951.

[b] Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, U. S. Department of Agriculture. Report of a study made under the Research and Marketing Act of 1946.

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the aqueous layer and dried with anhydrous sodium sulfate; the peroxides were determined in an aliquot containing 1 g. of solids.

Experiments with antioxidants other than Tenox II were concerned only with preparation of creamed turkey rather than both the preparation and storage. In the experiments the procedure was the same as above with the following exceptions: The amount of propyl gallate and/or butylated hydroxyanisole used was equivalent to their concentrations in Tenox II. Thus, propyl gallate was added at 0.001% and butylated hydroxyanisole at 0.0003% of the weight of the uncooked bird. The amount of NDGA used was 0.001%. The cream sauce was prepared with turkey broth and skim milk (3:1), and turkey fat. The sauce and diced turkey meat were combined in a ratio of approximately 3:1. Peroxide values on the fat of the creamed turkey were determined as before but rancid off-flavors were not determined.

RESULTS

Effect of cooking turkey with an antioxidant on peroxide value of the rendered fat. When halves of 6 turkeys held at —30° F. (—34° C.) for less than a month were cooked without an antioxidant, the peroxide values of the fat rendered during cooking ranged from 9 to 34. Halves of these same turkeys cooked with 0.005% Tenox II added to the cooking water had peroxide values of 0. Halves of two turkeys held at —30° F. for 6 months, and cooked with an antioxidant also showed no peroxide development in the rendered fat. A half of one of the same turkeys cooked with antioxidant after 12 months at —30° F. had a peroxide value of 5.

Effect of cooking turkey with Tenox II on flavor and peroxide value of frozen creamed turkey. Creamed turkey prepared from half turkeys cooked with Tenox II showed little or no rancid off-flavor and only low peroxide values when examined immediately after freezing or after storage under varying temperature and packaging conditions for 4 to 12 months (Table 1). In all cases the peroxide values of the experimental samples prepared with an antioxidant during cooking were the same, within experimental error, as that of the control samples (Tables 1 and 2). Flavor scores for those samples differed from the control samples only after 12 months of storage, and even then the difference was slight. Control turkeys were held at —30° F. for Experiments 2, 3, and 5 and cooked with an antioxidant at the end of all periods. Because of probable variations between lots of birds, these birds were considered to be better controls than fresh controls from another lot.

The degree of off-flavor and peroxide value in the creamed turkey prepared from the halves cooked without antioxidant were not the same in the different experiments when examined immediately after freezing. In Experiments 2 and 3, using different turkeys from the same lot, there was no detectable rancidity, although the peroxide values were higher than those of the halves cooked with an antioxidant. In Experiment 5 there was distinct rancidity in the unstored frozen creamed turkey and the peroxide values were correspondingly higher than those of Experiments 2 and 3. In Experiment 1, where hydrogenated vegetable oil was used in the sauce in place of turkey fat, a slight rancidity was detected but was not detected in the sample cooked with an antioxidant.

The creamed turkey prepared from the halves cooked without an antioxidant were distinctly rancid after

TABLE 1

Effect of cooking turkey with Tenox II on rancidity of creamed turkey before and after frozen storage

Experiment no.[c]	Storage temperature	Storage time	Peroxide value of fat in creamed turkey		Off-flavor score [d] of creamed turkey	
			With antioxidant	Without antioxidant	With antioxidant	Without antioxidant
	° F.	*months*	*meq./kg.*	*meq./kg.*		
1a	....	0	....	....	0.7	1.2
	10	4	....	....	0.4	1.6[e]
1b	....	0	....	....	0.2	0.7[e]
	10	4	....	....	0.5	1.4
2	....	0	1	8	0.3	0.2
	10	6	1	11	0.4	3.4[f]
	0	6	1	11	0.4	3.2[f]
	0	12	1	18	0.1	4.3[f]
3	....	0	4	11	0.3	0.3
	10	6	3	35	0.2	5.3[f]
	0	6	4	36	0.3	4.3[f]
	0	12	5	43	0.1	5.3[f]
5a	....	0	3	37	0.5	2.9[f]
	0	6	3	53	0.2	4.4[f]
	....[g]	2	4	77	1.5	9.4[f]
5b	....	0	3	43	0.5	2.8[f]
	0	6	6	66	0.2	5.4[f]
	....[g]	2	4	71	1.5	8.9[f]

[c] Creamed turkey for Experiments 1 and 2 was stored in cans; commercial packaging materials were used in other experiments. Hydrogenated vegetable oil was used in the sauce for Experiment 1; turkey fat rendered during simmering of the turkeys was used in other experiments.

[d] 0 indicates no off-flavor, 10 indicates extreme off-flavor.

[e] Difference in scores statistically significant (P equals 0.05).

[f] Difference in scores statistically highly significant (P equals 0.01).

[g] Samples stored for 6 months at 0° F., then at 10° F. for 6 months.

TABLE 2

Quality of creamed turkey prepared from control birds cooked with Tenox II

Experiment no.	Storage time at —30° F. (Uncooked turkey)	Peroxide value of fat in creamed turkey	Off-flavor-score of creamed turkey
	Months	*meq./kg.*	
2	6	1	0.2, 0.1
3	6	1	0.1, 0.2
2, 3	12	7	0.4, 0.2
5	6	5	0.6, 0.1
5	12	5	0.9, 0.2

storage when turkey fat was used in the sauce, even when no rancidity had been detected originally in the unstored creamed turkey (Experiments 2 and 3). Differences between the two treatments were less in Experiment 1, where the turkey fat was not used, than in the subsequent experiments. The peroxide values of the creamed turkey samples increased during storage in all cases when the turkey had been cooked without an antioxidant, if the creamed product was stored in containers other than cans (Experiments 3 and 5). The peroxide values increased very little on storage of the creamed turkey in cans (Experiment 2, Table 2), although flavor scores indicated a pronounced change had taken place. Since different turkeys were used in each experiment it is possible that the difference in peroxide development could be related to differences in turkeys. However, since turkeys for Experiments 2 and 3 were from the same lot, it is probable that the difference was due to differences in packaging conditions. Similar effects of packaging have been reported previously *(1)*.

Relative stability of frozen creamed turkey prepared with antioxidant addition at two different stages of preparation. The stability of samples pre-

pared with the following variations in treatment was studied:

Treatment No.	Antioxidant (Tenox II) addition
1	None added
2	In preparation of sauce only
3	To the cooking water only
4	To both cooking water and in preparation of sauce

Meat, fat, and broth from half of each of three turkeys cooked without antioxidant were divided equally for use in Treatments 1 and 2. The meat, fat, and broth from the other halves of the three turkeys cooked with an antioxidant were similarly divided for use in Treatments 3 and 4. Whenever an antioxidant was used, the amount was 0.005%, based on the weight of the uncooked birds. The creamed turkey from Treatments 2 and 3 above, therefore, had equivalent amounts of antioxidant, but it was added at different stages of preparation, and that from Treatment 4 had double the amount found in Treatments 2 and 3. Each of the 4 treatments was packaged in 2 ways, indicated in Table 3.

The creamed turkey prepared from the turkey cooked with the antioxidant (Treatment 3, Table 3) showed no rancidity immediately after freezing, or after 6 months of storage at 0° F. (—18° C.) and only slight rancidity after another 6 months of storage at 10° F. (—12° C.), indicating that the amount of antioxidant used during cooking afforded adequate protection from rancidity development during storage. Flavor differences between the samples cooked with an antioxidant and those cooked without an antioxidant but with antioxidant added to the sauce were not statistically significant after 6 months of storage at 0° F. However, in all cases the trend of flavor scores as well as the peroxide values showed less rancidity when the turkey was cooked with the antioxidant. After 12 months of storage at 10° F. the samples prepared by addition of antioxidant during preparation of the sauce were significantly more rancid than the samples cooked with antioxidant even though the peroxide values did not increase during this time. These results illustrate the greater effectiveness of antioxidant when present during cooking (and storage) rather than when added after cooking. The peroxide values and the off-flavor scores obtained for unstored samples containing no antioxidant were the highest encountered in any experiment. The variations from experiment to experiment or from bird to bird as already indicated may be rather large.

Effect of individual and mixtures of antioxidants on peroxide development during cooking of turkey and preparation of sauce. All of the antioxidant treatments reported in Table 4 effectively retarded peroxide development during cooking except for the treatment with propyl gallate. However, in another experiment with propyl gallate, the fat in the half bird cooked with the antioxidant had a peroxide value of 2.4, whereas the fat from the control had a value of 12.3. Evidently the antioxidants listed in Table 4 are effective to varying

TABLE 3

Relative stability of frozen creamed turkey prepared with antioxidant addition at two different stages of preparation. The stored samples were held at —18° C. (0° F.) for 6 months and then at —12° C. (10° F.) for another 6 months

Antioxidant addition	Packaging	Peroxide values at			Off-flavor scores [h]		
		0 months	6 months	12 months	0 months	6 months	12 months
		meq./kg.	*meq./kg.*	*meq./kg.*			
1. None (Control)	Cellophane [i]	37	53	77	2.9	4.4	9.4
	Visqueen [j]	43	66	71	2.8	5.4	8.9
2. In preparation of sauce only	Cellophane	19	21	19	1.0	0.7	3.4
	Visqueen	24	23	21	1.1	1.3	2.8
3. To the cooking water only	Cellophane	3	3	4	0.5	0.2	1.5
	Visqueen	3	6	4	0.5	0.2	1.5
4. Both to cooking water and in preparation of sauce	Cellophane	4	3	4	0.6	0.6	1.3
	Visqueen	4	5	4	0.6	0.3	1.5

[h] See footnote [d], Table 1.
[i] MSAT cellophane bags in cardboard carton with heat-sealed waxed paper overwrap.
[j] Visqueen bags with overwrap of parchment paper.

TABLE 4

Effect of individual and mixtures of antioxidants on peroxide development that occurs during cooking of turkey and during preparation of creamed turkey therefrom

Antioxidants added		Peroxide values of fat		Peroxide values of fat in creamed turkey when antioxidant was added during			
		Antioxidant added during					
Name	Concentration when present	None added	Cooking of bird	None (control)	Cooking of bird	Preparation of sauce	Cooking and preparation
	%	*meq./kg.*	*meq./kg.*	*meq./kg.*	*meq./kg.*	*meq./kg.*	*meq./kg.*
Butylated hydroxyanisole plus Propyl gallate plus Citric acid	0.001 0.0003 0.0002	6	0.0	19	6	10	....
Butylated hydroxyanisole plus Propyl gallate	0.001 0.0003	17	7	29	9	17	9
Butylated hydroxyanisole	0.001	13	8	23	10	14	8
Propyl gallate	0.0003	4	4	16	13	12	8
Nordihydroguaiaretic acid (NDGA)	0.001	24	4	32	13	26	11

degrees in retarding peroxide development. Because of the large bird-to-bird or sample-to-sample variations, there is at present considerable uncertainty concerning relative degrees of effectiveness.

CONCLUSIONS

Sufficient rancidity may develop during the cooking (simmering) of turkey to be readily detected after it has been creamed. The degree of rancidity development differs for different lots of turkeys and apparently also for individual turkeys in the same lot. The presence of an antioxidant during the cooking of turkey to be used in precooked frozen foods markedly retards the development of rancid flavors and peroxide during both cooking and subsequent frozen storage. Addition of the antioxidant during preparation of the cream sauce rather than during cooking of the turkey less markedly retards development of rancid flavors during storage. Thus the greatest over-all benefit is obtained by adding the antioxidant at the beginning of the cooking process.

Acknowledgments

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Preservation of Very Small Fish in the Philippine Islands[a]

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Philippine Fishery Program of the U. S. Fish and Wildlife Service

(Manuscript received May 28, 1951)

The methods of preservation of very small fish in the Philippines are discussed. These methods include drying, salting, smoking, cooking, and fermenting. Improvements to the modes of preservation are described.

Conforming to the dietary pattern usual in most oriental countries, the primary food of the Filipino is rice, with fish as the major source of protein. When the resident Japanese were driven from the Philippine Islands after the last war, the 25,000,000 natives living on the 7,000 islands of the country were starved for fish despite the over 2,000 species of fish that dwelled in the waters about them. To help fill the void left in the fish capture and preservation fields by the departure of the Japanese, the U. S. Government established the Philippine Fishery Program of the U. S. Fish and Wildlife Service. Its mission was to assist in the rehabilitation of the Philippine fisheries during the period from 1947-1950 by research in fish capture, pondfish growth, fish biology, oceanography, and fish preservation. The United States Government also sponsored 125 young Filipinos during a year of fisheries training in United States industrial and educational institutions so that they could bring modern methods of fish production to the Philippines.

Dependent on the weather trends or monsoons, the Philippine fish production is seasonal in the different areas of the islands. Fish are being caught or raised somewhere in the Islands all through the year, but the inadequate transportation and refrigeration facilities necessitate considerable preservation work to keep the fish during their transport to areas of scarcity, or during storage until the gluts disappear. Although some fish is frozen, it is thawed and passed off as fresh fish for selling purposes. Ice and refrigeration are very expensive and not used to the extent that they should be. Cans are expensive and hard to obtain so that very little canning is done. Consequently, the burden of fish preservation is carried by those methods which utilize a maximum of labor and a minimum of raw material, other than fish.

The Filipino fisherman will catch every fish he can, regardless of its age, size, or sexual maturity. He catches fish ranging in size all the way from the macroscopic plankton shrimp to the great tiger sharks, without regard for the demands of conservation. The Philippine Bureau of Fisheries battles constantly against the irresponsible depletion practices but it is a losing fight for such a small group to cover an area so large. Every stream, lake, or body of sea within sight of land is combed by explosives, poisons, fine mesh nets, and traps. Everything that is living and can be seen by the naked eye is kept. Snails are fed to the ducks, small eels and worms are used for bait, and anything that cannot be eaten, worn, or built into houses or furniture is dried, ground, and used for fertilizer.

A greater part of the large fish are eaten fresh while most of the small fish are processed in some way. It is with the preservation of these small fish that this paper is concerned.

After the fry and immature fish have been removed from the water they must be processed quickly or they spoil, thus the fishing boats returning from the fishing grounds are met by the processors who bargain for the catch and carry it to their nearby beckyard or underhouse factories where it is dried, salted, smoked, steamed, pickled, or fermented.

[a] Presented at the Eleventh Annual Meeting of the IFT, New York, N. Y., June 19, 1951.

[b] Present address: U. S. Naval Supply Research and Development Facility, Naval Supply Depot, Bayonne, N. J.

DRYING

Most of the small fish are not salted or eviscerated prior to drying. After a quick wash in water at the beach, the fish are laid out in a single layer on long split bamboo mats or oblong bamboo trays and are sun-dried. Few if any fish are dried by artificial heat. Two or three times during the day the fish are stirred with a shell or piece of cardboard. One day of drying is usually sufficient for very small fish. While most fish are dried individually, some, such as Sinarapan, are dried en mass in small circular mats. Usually, fish dried without salting suffer some belly disintegration and a strong unpleasant flavor develops. Most of our work with the drying of small fish was concerned with trying to get the natives to use a short brining period and some degree of evisceration to increase storage life and acceptability.

SALTING

Fish are salted to add flavor and to preserve them during transportation to some particular point or until they are smoked, cooked, pickled, or fermented. The amount of salt added to the fish is directly proportional to the length of time the fish must be kept and is not affected by flavor considerations. Some fish are dry salted while others are brine salted. Our program in this field was devoted, for the most part, to improving the native methods of making salt. Native salt is only 88-95% pure sodium chloride. Since 1% of other sea salts is deleterious to salted fish, salt with 5-12% impurities imposed a tremendous handicap on the Filipino fish processor.

SMOKING

Smoked fish or tinapa in the Philippines is a delicacy and many of the small and medium sized fish are smoked. The fish are usually slightly washed in harbor water, cooked in a medium brine, sun or air dried to remove surface moisture, and then are smoked in baskets with a diameter of 14-16 inches, over small individual fire pots. The fish as they go to market sometimes remain right in the smoking baskets. Our efforts in this field were devoted to developing methods for hot and cold smoking many species of fish not at present prepared in this manner, developing a cold brine method of salting the fish, and constructing smoke houses that could do a better controlled and more economical job of smoking fish. Some of the products smoked with considerable success were shrimp, oysters, spiny lobsters, barracuda, tuna, sailfish, sardines, anchovies, gobies, gizzard shad, and many others.

COOKING

Steamed or cooked fish and pickled fish are of minor importance and the Philippine Fishery Program did little work on them but as the former process may be of interest to some, the process is described. An earthenware pot is filled with 6-10 inch fish without evisceration or washing. A bamboo mat keeps the fish off the bottom and about an inch of water provides the cooking steam which is held in the pot, to some extent, by an earthenware lid. The cooking time is dependent on the size of the fish, the size of the pot, and the amount of heat available. After the cooking, the liquid may or may not be poured off and the fish is sent to market in the same pot. It will keep about 7 days.

FERMENTING

Fermented fish are quite popular and the preparations take a variety of forms. One utilizes very small shrimp which are partially dried, salted, mixed to a paste by human feet, dried again, and then are molded into blocks which may be sliced and sold in the public market after a short period of fermentation. The product looks like a lavender shade of meatloaf. Another method utitlizes small fish, shrimp, oysters, clams, or big-fish viscera. The fish is mixed with salt in a ratio of about 3 or 4 to 1 by weight. The resultant mixture is placed in earthenware pots, kerosene cans, oil barrels, or large wooden vats and allowed to stand at air temperature for 1-15 months. The only sanitary precautions observed are desultory efforts to prevent the entrance of flies. At the end of the incubation period, the proteinaceous liquid or patis is drawn off, strained, and sold as a sauce like soy sauce while what remains of the fish is ground and sold as a thick sauce, called bagoong. Sometimes the patis is cooked before bottling. Some operators add saturated brine to the semi-disintegrated fish left after the first extraction of sauce, and this is left to stand for a couple of weeks. Then another extraction of sauce is made. While the first extraction may be 9-10% protein, the next may be about 6%, a third about 3%, and the fourth negligible in soluble protein content.

The problem concerning patis and bagoong was to shorten the incubation from the 6 or more months necessary to produce a good product, down to a period of one month or less. Bacteriological examination showed that the initial bacteria population dropped rapidly as the fermentation continued, until toward the end of the period the mixture was practically sterile. A great variety of proteolytic enzymes was tried, but as expected, most of them were inactivated by the salt. To determine the effect of temperature on incubation time, tests were made using various incubation temperatures. Here considerable success was obtained and finally a process was settled on which called for incubation at 116° F. (47° C.) for one week and 37° F. (25° C.) for two weeks. It is true the flavor was not quite as fulsome, but the amount of protein in solution was as great as the 9-month product formerly contained. It was also determined that the flavor was improved by exposing it to the air as little as possible.

There are numerous other products made locally throughout the Islands, but for the most part they are variations or combinations of those mentioned above.

If any of the fish processors in the United States are worried about competition from the Philippines, they can rest at ease for the Philippines are going to be importing fish as long as they have dollar credits, and after that they will have to do without. The Philippines have numerous fine tuna but it will be decades before the Filipino fisherman can be trained to go out of sight of land to the best fishing grounds and until the bait areas are charted to the extent that large scale commercial fishermen and canners can set up shop. It is only from those areas not now fished, and by increased cultivation of fishponds that the Philippines will ever achieve surplus fish for export.

Deterioration of Orange Oil[a]

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(Manuscript received May 18, 1951)

Observations were made on orange oil emulsions stored at 145° F. (63° C.) and results of organoleptic and chemical determinations are presented. The effect of various stabilizers on rate of deterioration is shown. An adaptation of iodometric methods is presented which is useful for following oil deterioration. A chain mechanism for auto-oxidation of d-limonene is postulated.

Orange oil is widely used in flavoring a variety of food products. The oil is obtained in large quantities as a by-product of the orange juice industry. It is extracted from the fruit peel either by distillation or by expression. The oil undergoes an odor deterioration brought about by air oxidation, producting "off" odors which are commonly described as "terpeney." This is an old problem for the food industry. In addition, during storage of canned orange juice, undesirable flavor changes are encountered which have been attributed to the auto-oxidation of orange oil. Volatile oil in fresh orange juice adds to its flavor and odor, while juice prepared with the elimination of all peel oil tastes "flat" and is lacking in aroma. However, the presence of small amounts of oxidized oil in canned orange juice gives rise to objectionable off-flavors.

The problem, then, is to find a practical antioxidant so that a more stable orange oil may be derived for use in the food industry. The investigation described in this paper is an approach to this problem and also suggests a mechanism for the oxidation process.

EXPERIMENTAL

Emulsions of orange oil in water stabilized by gum tragacanth were prepared. The cold-pressed orange oil used was obtained from the Research Laboratories of the Florida Citrus Canners Cooperative at Lake Wales. Emulsions were prepared in a micro Waring blendor from 7.5 cc. of orange oil containing the potential antioxidant at a concentration of 0.05 g. per 100 cc. of oil, 0.5 g. of gum tragacanth and 42 cc. of distilled water. Propyl gallate, NDGA (nordihydroguaiaretic acid), vanillin and ethyl vanillin were tested at the above concentrations. Ethyl vanillin was also tested at a concentration of 0.1 g. per 100 cc. of oil.

The emulsions, prepared in duplicate, were transferred to 16-oz., scrupulously clean bottles which were closed by loosely screwed lids. The cap, from which the liner was removed, was made of lacquered electrolytic tinplate. Samples were incubated at 145° F. (63° C.) and examined daily.

It was found that "terpeney" odor could best be detected organoleptically when the sample was cooled to about 41° F. (5° C.) prior to examination.

The method of Nozaki *(4)* for the determination of organic peroxides was adapted and used as follows: To 4.0 g. of sample in a 250-cc. Erlenmeyer flask 20 cc. of 1:1 by volume mixture of acetic anhydride and chloroform and about 0.3 g. of sodium iodine were added. The mixture was swirled to insure complete mixing and exactly two minutes later 100 cc. of water and 2 drops of an emulsifying agent such as Monsanto's AE-1 were added. The liberated iodine was titrated with 0.01 *N* sodium thiosulfate solution and end point was determined by using starch as indicator. During the titration, the mixture was well stirred by means of a magnetic stirrer which insured the removal of all of the iodine from the chloroform layer. The use of an emulsifying agent and a magnetic stirrer are a great aid in obtaining a well-defined end point. A blank determination was found to be unnecessary.

Various other solvents have been described in the literature for use in the determination of peroxides. Acetic acid has been used extensively but has always proved troublesome because of the rapid oxidation of iodide ions by air, therefore the determination is carried out in an inert atmosphere *(2)*. Alcohols such as propanol-2 do not require protection from air but the reaction is slow and the solution must be brought to incipient boiling *(3)*. The iodide-peroxide reaction is fast in acetic anhydride. Figure 1 shows that the reaction was complete in 2 minutes at room temperature when the method was used on slightly rancid lard. Previous work had shown reaction rates to be reproducible.

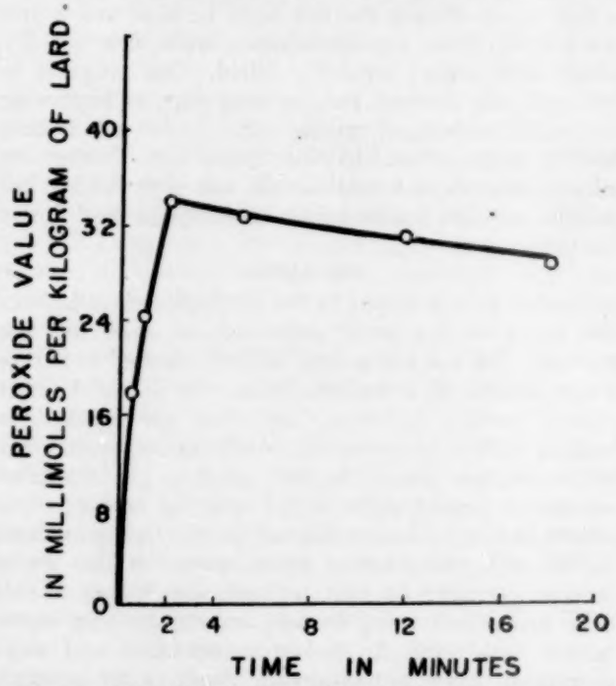

Figure 1. Reaction between sodium iodide and peroxides in rancid lard using acetic anhydride-chloroform solvent.

RESULTS

The data in Table 1 show that changes in organoleptic terpeniness are followed closely by changes in peroxide value. From the results obtained it is felt that the critical peroxide value is about 20 millimoles per kg. of oil, and the end of the induction period is reached when the peroxide value rises sharply after a value of 20.

Bleaching of the carotenoid pigments was observed to follow terpeniness closely. When the emulsion became white throughout, incipient organoleptic terpeniness generally appeared on the following day. The bleaching is undoubtedly a diffusion-controlled rate process as indicated by the fact that the bleaching is first observable at the air-liquid interface, followed by a gradual lighten-

[a] Presented before the XIIth International Congress of Pure and Applied Chemistry, September 11, 1951, New York, N. Y.

[b] Present address: Kingan and Co., Indianapolis, Indiana.

TABLE 1

Evaluation of antioxidants for orange oil

Added anti-oxidant	Days to incipient "terpeney" odor	Days to incipient pitting of lid	Days to bleach		Peroxide values (millimoles of peroxides per kg. of oil) at indicated days						
			Top layer	Whole sample	3	4	5	6	8	16	20
None (control)	5	5	2	5	3.19	5.30	15.19	19.00	141.0	....	....
Vanillin (0.05%)	6	6	2	5	4.48	....	11.08	15.00	49.6	....	....
Ethyl vanillin (0.01%)	6	6	2	5	0.70	6.39	13.75	19.73	92.8	....	....
Ethyl vanillin (0.10%)	7	7	2	5	1.70	4.15	9.49	13.74	59.5	....	....
Propyl gallate (0.05%)	20	20	..	20	0.0	0.0	0.0	0.0	0.0	0.0	21.4
NDGA (0.05%)	20	20	..	20	0.0	0.0	0.0	0.0	0.0	0.0	32.5

ing of color from the top down through the body of the emulsion.

An interesting accompanying phenomenon was found in the tinplate lid pitting which was observed on the first day of the appearance of terpeney odor. At this time only a small pitted area appeared. On continued storage this area gradually enlarged until the entire cap surface was badly corroded as shown in Figure 2.

Figure 2. The gradual attack (from left to right) upon tinplate lids which accompanies onset of "terpeniness" in orange oil.

Apparently the production of corrosive vapors such as acids or aldehydes accompany the onset of terpeniness.

Change in peroxide values with incubation time is illustrated in Figure 3 for the samples with vanillin, propyl gallate and the control samples. The data indicate that a self-catalyzed chain mechanism takes place during the auto-oxidation of limonene, which comprises about 90% of orange oil. Proctor and Kenyon *(5)* have shown by infrared absorption studies that carveol and carvone are products of the oxidation of limonene and that they are chiefly responsible for the "terpeney" odor. A suggested path for this reaction, similar to that suggested for the auto-oxidation of unsaturated fats and fatty acids by Farmer *(1)*, is via the hydroperoxide as shown in Figure 4. This chain reaction is initiated by

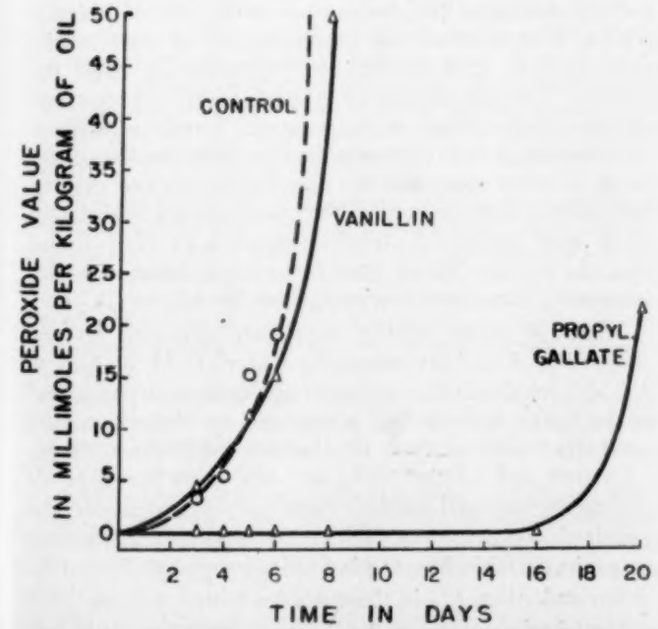

Figure 3. Formation of peroxides in orange oil as affected by antioxidants.

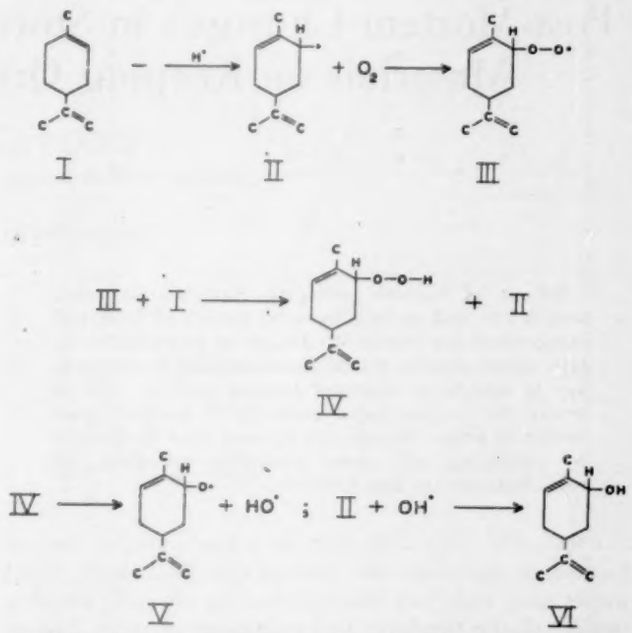

Figure 4. Suggested scheme for the oxidation of limonene, I, to carveol, VI, by a free radical chain mechanism.

the abstraction of hydrogen atom from limonene, I, by any one of a number of ways. The resulting radical, II, may combine with atmospheric oxygen producing another free radical, III. The reaction of III with limonene, I, is crucial to the chain reaction since in this step we have not only the formation of the 2-limonyl hydrogen peroxide, IV, but also the production of further quantities of the free radical II. It is seen that the regeneration of II is necessary in order to maintain the chain cycle. If 2-limonyl hydrogen peroxide, IV, decomposes by a homolytic oxygen-oxygen bond cleavage, the free radical, V, and hydroxyl will be formed. The combination of II with hydroxyl will produce carveol, VI. This is a chain-terminating step. From the above reactions it is apparent that if it is to function as a chain breaker, an antioxidant must promote the removal of II, III, V, or hydroxyl.

SUMMARY

1. NDGA and propyl gallate protected orange oil against oxidative deterioration under the conditions of the test but vanillin and ethyl vanillin did not offer comparable protection.

2. Appearance of "terpeney" odor was accompanied by rise in peroxide value and bleaching of carotenoid pigments present in fresh oil.

3. A method for determination of peroxides in auto-oxidized edible oils is presented.

4. An interesting accompanying phenomenon was observed in the pitting of the tinplate lids used. The pitting appeared simultaneously with the onset of terpeniness.

5. A mechanism whereby limonene is auto-oxidized to carveol through limonene hydroperoxide is postulated.

Acknowledgments

The authors wish to express their thanks to Dr. James H. Saunders of Monsanto Chemical Company for his valuable suggestions and to Mr. Robert A. Nanz of Florida Citrus Canner Cooperative for kindly furnishing samples of fresh orange oil and helpful suggestions.

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Post-Mortem Changes in Stored Meats. IV. Effect of Packaging Materials on Keeping Quality of Self-Service Meats[a,b]

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(Manuscript received May 28, 1951)

Effects of various packaging materials on color, weight loss, and surface bacterial growth of fresh and cured meats are described. Ability of materials to retain carbon dioxide within the atmosphere of the package is related to improved keeping quality. Use of wraps that prevent rapid exchange of enclosed gases results in longer storage life of meat than is obtained by packaging with more permeable materials, but color changes are less desirable.

Films and foils that may be considered for use as packaging materials for self-service fresh and cured meats vary widely in those properties affecting keeping quality of the product. Color changes of meat, loss of moisture, and surface bacterial growth are factors involved in spoilage that occur to a greater or lesser extent depending upon inherent characteristics of the wrap.

Discoloration of packaged meats has been investigated by several workers. According to Lavers *(12)*, color changes of red meats held at refrigeration temperatures are not caused by one specific wrapping film, but result when any packaging material is used. The sequence of reactions leading to discoloration of fresh and cured meats has been described by Jensen *(11)*. In studies with sliced boiled ham, Urbain and Ramsbottom *(18)* showed that color protection was best secured through exclusion of oxygen. The effect of atmospheric oxygen in the discoloration of cured meats was demonstrated by Urbain and Jensen *(19)*. The findings of Brooks *(5)* indicate that a definite optimum pressure exists for oxidation of the natural pigment hemoglobin, whereas the rate of oxidation of the cured meat pigment is proportional to oxygen pressure.

The ability of carbon dioxide to retard reproduction of organisms which cause surface deterioration of meat was recently demonstrated by Ogilvy and Ayres *(13)*, and substantiated the findings of many earlier investigators. They showed that the storage life of chicken was prolonged as carbon dioxide concentration was increased. Carbon dioxide was particularly effective as storage temperatures were reduced. Levels of carbon dioxide higher than 25% resulted in discoloration of the flesh, a defect observed by Brooks *(4)* in the case of beef when concentrations of the gas above approximately 20% were employed. The same workers *(14)* found that the storage life of frankfurters was lengthened by increasing concentrations of carbon dioxide.

Although many studies have been reported on the properties of various packaging materials *(3, 6, 7, 8, 9, 10, 16)*, relatively few of these have dealt with the actual performance of materials when used as wraps for food products. The quality of cherries was observed by Gerhardt and Lindell *(10)* to vary with the type of packaging material used. Platenius *(16)* calculated the required oxygen permeability of films for packaging several vegetable items; his findings were confirmed by Allen and Allen *(1)* in their studies with tomatoes. The bacteriological requirements of food packaging materials were summarized by Barail *(2)* who emphasized the

[a] Presented at the Eleventh Annual Meeting of the IFT, New York, N. Y., June 19, 1951.

[b] Journal Paper No. J-2046 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 1161.

need for rendering these wraps bacteriostatic and fungistatic to prevent contamination of the product.

EXPERIMENTAL

Frankfurters used in cured meat studies were obtained from the following sources: 1, skinless, uncolored, dried skimmilk-added frankfurters were received from a packing house [c] on the day following manufacture; and 2, similar frankfurters in 1 pound cellophane-wrapped packages were purchased from local retail stores.

Pliofilm FF-120, Flexvac-183A (a laminate consisting of FF-Pliofilm on the inside of the package and moisture-proof cellophane on the outside), and an outer sheet of 0.0015 inch aluminum foil laminated to Pliofilm 120 N 1 on the side in contact with the meat were utilized as packaging materials. In tests using Pliofilm FF-120, the samples were placed in open bags and exposed to 96% carbon dioxide for one day. The bags were heat sealed to one-hole rubber stoppers fitted with glass and rubber tubing. Heat sealing was facilitated by an application of Polyamide Resin 95 [d] and Cenco Tackiwax to the stoppers. The packages were evacuated and carbon dioxide was added, at a controlled rate by employment of flow meters. The initial concentration of the gas approached 92%, as determined by analysis with a Fisher Unitized Precision gas analyzer. Details of evacuation and gassing procedures were described by Ogilvy, Burke, and Ayres *(15)*. Samples were stored in a gas-tight chamber equipped with a Cambridge Carbostat carbon dioxide analyzer, at a temperature of 7.2° C. (45° F.), and removed for microbiological examination periodically. Spoilage was indicated by surface slime or the appearance of mold on the frankfurters. Analyses of the atmospheres of the packages were made for carbon dioxide concentration immediately before samples were removed for bacteriological counts. Control samples were not exposed to high carbon dioxide concentrations but were packaged in air, similarly stored, and were examined at the same time as those packaged in gas. Relative humidity was controlled in the chamber by means of a sulfuric acid solution. In trials wherein Flexvac and aluminum foil-pliofilm laminate films were used as wraps, the frankfurters were given a preliminary two-day exposure to carbon dioxide; the temperature of storage was 4.4° C. (40° F.).

In studies with fresh meats, round and short steaks were purchased from local grocery stores and were cut in the laboratory into pieces of uniform size. Precautions were taken to prevent contamination from cutting tools or the chopping block. Samples were packaged in MSAT-80 cellophane, aluminum foil, Pliofilm FF-120, Parafilm M, waxed paper, LSAT cellophane, Flexvac-183A, Saran A-517, Cry-O-Rap, and the aluminum foil-pliofilm laminate previously described. Packages were stored at 4.4° C. (40° F.). Samples were examined at intervals for discoloration, off-odor, and slime formation. Surface bacterial counts were made by swabbing a definite area of meat surface and counts were reported as the number of bacteria per square centimeter. A cork borer was used to cut holes having an area of 2 sq. cm. in filter paper strips; a strip prepared in this way was placed on the meat surface and a moistened cotton swab rolled over the enclosed area several times. The swab was aseptically transferred to a dilution bottle containing 100 ml. of sterile water and serial dilutions of the mixture were used in making pour plates. This method was also used to determine contamination due to packaging materials. Changes in weight of samples were recorded.

Storage end points were based on observance of undesirable color, off-odor, slime formation, and a given value for the numbers of microorganisms per square centimeter of meat surface.

Studies on the effect of carbon dioxide on packaged fresh meats were carried out with MSAT-80 cellophane, Pliofilm FF-120, and 0.0015 inch aluminum foil laminated to Pliofilm 120 N 1. Substantially the same procedures for gassing as described for frankfurter experiments were employed, with the exception that the carbon dioxide concentration during the 2 day exposure period was 25%. Control packages contained no added carbon dioxide. Samples were stored at 4.4° C. (40° F.) and examined periodically.

RESULTS AND DISCUSSION

No apparent discoloration was observed when frankfurters were packaged in carbon dioxide. In some instances, a wrinkled appearance was noted. This has been ascribed by Ogilvy and Ayres *(14)* to be due to reduced pressures in the free gas space surrounding the frankfurters resulting from solution of a portion of this carbon dioxide in the meat.

When Pliofilm FF-120 was used as the packaging material, frankfurters treated with carbon dioxide and stored at 7.2° C. (45° F.) had a storage life approximately 1.5 times that of control samples packaged in air (Figure 1). Incipient spoilage was indicated by

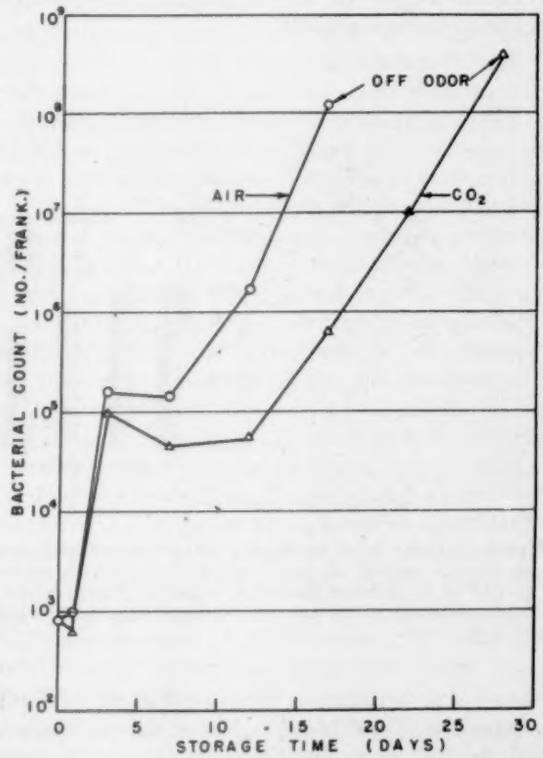

Figure 1. Effect of carbon dioxide in prolonging keeping time of frankfurters packaged with Pliofilm FF-120 and stored at 7.2° C. (45° F.). Surface bacterial counts of frankfurters having approximately a 90 sq. cm. surface area and weighing about 50 g.

mold growth, which occurred on control frankfurters after 16 days in storage, but was not observed on treated samples until the 26th day. An interesting feature noted was that the concentration of carbon dioxide in control packages was approximately equal to that of the gassed packages at the time control frankfurters showed growth of mold. This raised the possibility that the carbon dioxide had been lost from the treated packages, and the lengthened storage life of gas-treated samples was believed to be due to the diffusion of carbon dioxide from the frankfurters to the atmosphere of the packages.

[c] Kindly furnished by the Rath Packing Co., Waterloo, Iowa.
[d] Supplied through the courtesy of General Mills Inc., Minneapolis, Minn.

Lowering of the pH by carbon dioxide may have contributed to the prolongation of storage life.

Flexvac and 0.0015 inch aluminum foil laminated to Pliofilm 120 N 1 were effective in retaining carbon dioxide within the package (Figure 2). It is known that laminated films and foils offer very effective barriers to gas transfer *(8)*. The increase in concentration of carbon dioxide in control packages reflects microbial activity. Ogilvy and Ayres *(13)* based keeping time of meat on the time required for a specified increase in levels of carbon dioxide. In view of the fact that bacterial counts were lower on control samples packaged with the aluminum foil-pliofilm laminate and the levels of the gas were higher than with Flexvac, the former material was probably less permeable to carbon dioxide than was Flexvac. Similarly, carbon dioxide analyses of gassed packages (made at the end of 13 days) indicated that the aluminum foil-pliofilm laminate was more effective in retaining the gas than was Flexvac. This observation might be of importance in considering longer term storage periods.

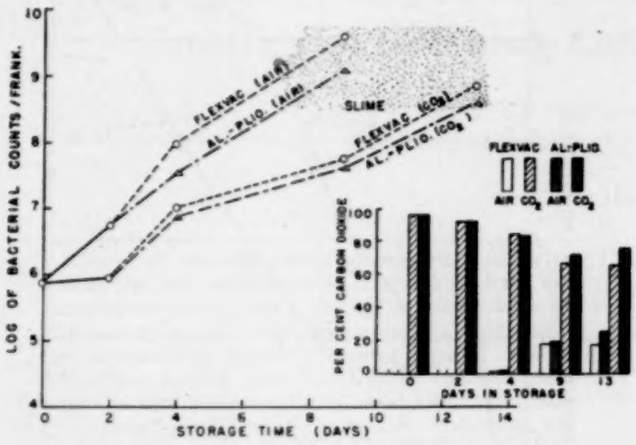

Figure 2. Relation of packaging materials and carbon dioxide on growth curves of bacteria on frankfurters stored at 4.4° C. (40° F.). Surface bacterial counts of frankfurters having approximately a 90 sq. cm. surface area and weighing about 50 g.

Bacterial growth curves illustrate that the preliminary gas exposure of frankfurters before the packages were sealed resulted in a delay in germination of bacteria as compared with control samples not subjected to such treatment. In the case of both packaging materials, the rates of growth of surface microorganisms were greater with meat packaged in air than with samples packaged in an atmosphere of carbon dioxide. Control samples were considered to be spoiled after 9 days in storage, at which time a watery slime was observed. Gas-treated frankfurters did not show sliming until the 13th day, or had a keeping time of 1.5 times that of the untreated samples.

Growth curves of bacteria found on the surface of fresh meats packaged with several types of materials are represented graphically in Figure 3. Each point represents the logarithmic average of bacterial counts per square centimeter of meat surface for 5 replicate samples. In these trials, incipient spoilage was indicated by onset of off-odor, which occurred when surface counts of meat samples approximated 10^7 organisms per sq. cm. In many instances, discoloration of samples was observed before disagreeable odors were detected. Discoloration therefore could not be correlated with organoleptic or microbiological evaluation as a means of determing storage end points. The keeping time of meats packaged with the aluminum foil-pliofilm laminate was 4 days longer than samples wrapped with MSAT-80 cellophane. This represented a 50% increase in storage life. Beneficial effects derived from packaging with the relatively gas-impermeable laminate of aluminum foil and pliofilm may be attributed to the low rate of ex-

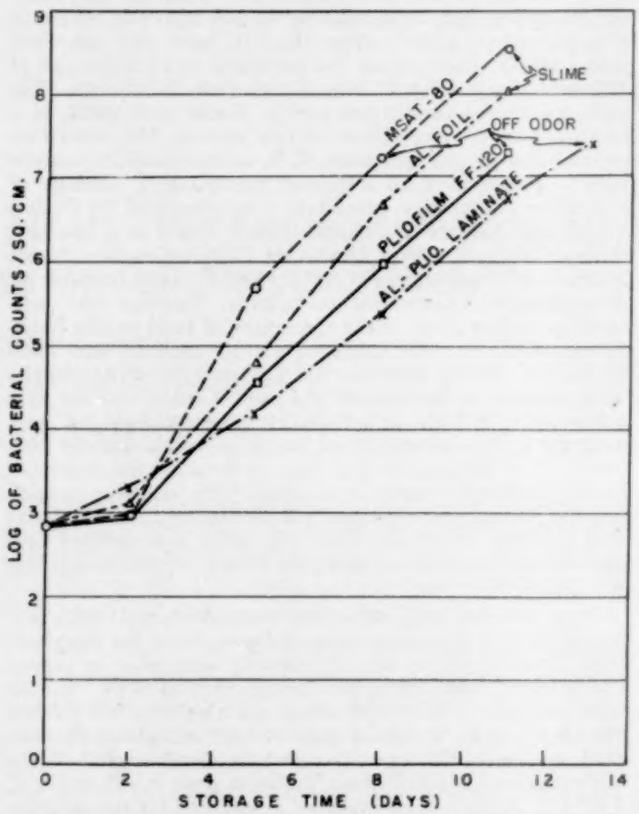

Figure 3. Relation of various films and foils to storage life of fresh sliced beef at 4.4° C. (40° F.).

change of gases within the package. Associated with this is the production of carbon dioxide by microorganisms, the effects of which become important if the gas is retained in the atmosphere of the package. Keeping times of meats packaged with the other test materials were intermediate in relation to samples wrapped with MSAT-80 cellophane and 0.0015 inch aluminum foil laminated to Pliofilm 120 N 1.

MSAT-80 cellophane was effective in preserving the bright red color of oxygenated beef for the first 3 days of storage; after that time brown discolorations were observed. In the early phase of the storage period this film permitted conditions favorable for retention of the desired color. However, during prolonged storage, oxygen pressure was reduced and subsequent oxidation resulted in a brown-discolored product. Dehydration also undoubtedly influenced development of discolora-

tion. Meat packaged in Pliofilm FF-120 exhibited a similar discoloration, with changes taking place earlier in the storage period. Samples packaged in Cry-O-Rap, Saran A-517, Flexvac-183A, and Parafilm M provided interesting illustrations of the course of color changes that commonly occur with fresh meats over a period of time. After 1 or 2 days in storage at 4.4° C. (40° F.), the central portion of samples examined was purple in color, indicating that the myoglobin was in the reduced state. It was in this general area that the meat was in the most intimate contact with the wrapping material, and air space was at a minimum. The oxygen pressure apparently was sufficiently low to permit the formation of reduced myoglobin from oxymyoglobin without further oxidation to metmyoglobin. Toward the outer edge of the meat, brown discoloration was observed as a narrow band extending over the entire meat surface and to a depth of 2 to 3 mm. In this region of the brown band, reduced myoglobin had undergone oxidation to metmyoglobin. The outermost edge, where oxygen pressure was high, remained bright red in color during the first few days of storage. By the end of the 12th day, all samples packaged with the above materials showed an increase in brown discoloration. On the other hand, aluminum foil and the aluminum foil-pliofilm laminate provided a reduced condition of the myoglobin, characterized by purple color of the entire meat surface. The purple color was evidenced throughout the entire storage period. When the meat was exposed to air, brightening occurred and the color resembled that of the beef immediately before it was packaged and stored.

Figure 4 shows bacterial growth curves for round steak packaged with MSAT-80 cellophane and the aluminum foil-pliofilm laminate. The curve obtained for meat wrapped with Pliofilm FF-120 was not as well defined. Bacterial counts and time for development of off-odor indicated that samples packaged with this film had a storage life longer than round steak wrapped with MSAT-80 cellophane, but did not keep as long as meat packaged with the laminate. The temperature of storage was 4.4° C. (40° F.). Samples packaged in an atmosphere approaching 96% carbon dioxide were subjected to a preliminary 2 day exposure to the gas at a level of 25%. This latter concentration of carbon dioxide apparently produced no deleterious effect on color during the 2 day exposure period, but subsequent brown discoloration was noted when the meat was removed from storage at the end of 4 days and at each succeeding interval. Control samples were held in the storage chamber for 2 days, in air, prior to packaging. These received no treatment with carbon dioxide.

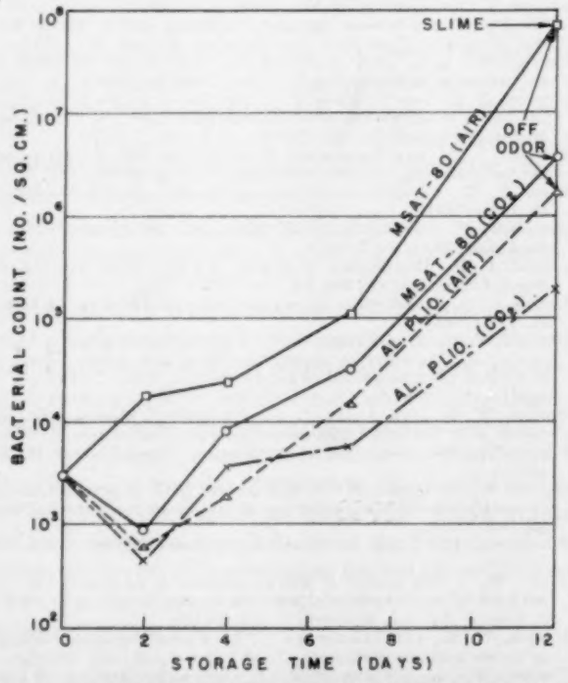

Figure 4. Effect of packaging materials and carbon dioxide on keeping time of fresh beef stored at 4.4° C. (40° F.).

Off-odor and slime formation were criteria used as indications of spoilage. In these trials, a surface count of approximately 2 x 10^6 organisms per sq. cm. correlated with the first detectable off-odor. Storage end points for gassed samples packaged with the laminate of aluminum foil and pliofilm were not determined. The use of carbon dioxide resulted in an increase in storage life of meat packaged with all materials tested. An observation of importance derived from these experiments is that initial exposure of meat to carbon dioxide before packaging was of value in prolonging storage life, since use of those materials having greater permeability to the gas resulted in an increase in keeping time. Presumably, as carbon dioxide passed through these wraps into the outer atmosphere, a portion of the gas diffused from the meat into the atmosphere of the package. It is not known to what extent the gas dissolved in the meat; an evaluation of this might be desirable in determining the effectiveness of carbon dioxide in prolonging storage life of meat initially packaged under a high concentration of carbon dioxide and later stored in air. Since visibility is requisite for self-service merchandising of meats, commercial application of carbon dioxide with opaque wrapping materials might require opening the packages and displaying the meat unwrapped. Another possibility is the use of a double wrap, the inner transparent material remaining after the outer opaque material is removed.

Changes in weight of packaged fresh meat are illustrated by Figure 5. Weight losses were negligible with all materials tested, except for those samples packaged with MSAT-80 cellophane, LSAT cellophane, and waxed paper. In several instances, a gain in weight was observed, due presumably to condensation of moisture on the outer surface of the bags. The cellophane wraps sacrificed moisture loss in order to maintain oxygenating conditions necessary for desirable color. With the exception of waxed paper, other materials were sufficiently moisture proof to prevent occurrence of appreciable dehydration. Weight losses of meat indicated that the humidity of the atmospheres within the packages varied with the material used; use of those wraps that failed to prevent dehydration undoubtedly resulted in lowered humidity conditions in the air space surrounding the meat. In his studies on the effect of humidity on growth of microorganisms, Scott *(17)* stated that

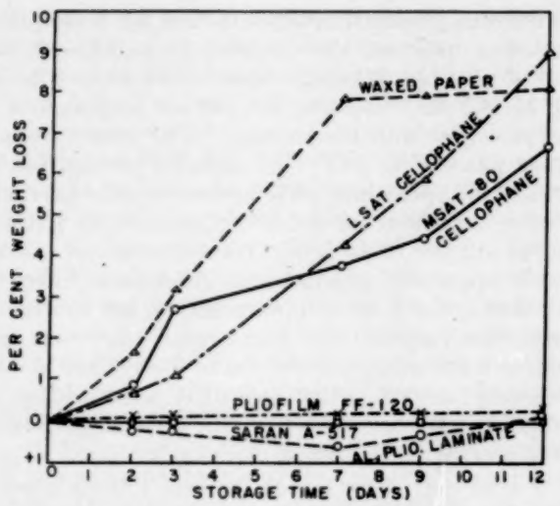

Figure 5. Changes in weight of fresh beef packaged with several materials and stored at 4.4° C. (40° F.).

the relative humidity at the surface of the meat would be higher than that of the surrounding atmosphere because of diffusion of moisture from the interior of the meat to the surface. This condition apparently prevailed when wraps permitting appreciable moisture loss were used as packaging materials. Desiccation did not proceed to the extent that levels of humidity inhibitory to bacterial growth were obtained; on the contrary, proliferation of microorganisms was most rapid with films that were ineffective as moisture barriers. These materials promoted aerobic conditions favorable for the growth of surface microorganisms. In addition, MSAT-80 cellophane was more permeable to carbon dioxide than aluminum foil laminated to pliofilm; spoilage of gas-treated meat packaged with the former material occurred earlier than that of samples similarly treated but packaged with the laminate.

While a packaging material may be highly effective in retarding one or several of the conditions that contribute to spoilage, it may not necessarily possess all of the properties requisite for preservation of meat. Films that permit oxygenating conditions necessary for maintenance of red color allow rapid growth of microorganisms on meat surfaces. Use of these materials is limited also by their inability to prevent dehydration. Development of new films for packaging meats might logically require that consideration be given to all factors contributing to spoilage.

SUMMARY

Storage life of frankfurters packaged with several wrapping materials was increased by high concentrations of carbon dioxide in the atmospheres of the packages, when storage was carried out at 7.2° C. (45° F.) and 4.4° C. (40° F.). The ability of materials to retain the gas was an important consideration; however, the meat did not spoil until some time after carbon dioxide had been lost from the packages. Preliminary exposure of frankfurters to the gas before packaging decreased the rate of growth of surface microorganisms.

Discoloration of packaged red meats was not correlated with other indices of spoilage. Materials found to preserve the desirable bright red color of meat in the early phases of storage permitted the most rapid proliferation of microorganisms on the surface of the samples. Meat packaged with all materials except aluminum foil or a laminate of pliofilm and aluminum foil developed brown discolorations when stored at 4.4° C. (40° F.). The time of appearance of discoloration varied with the wrapping materials used. Fresh meats packaged with aluminum foil or the aluminum foil-pliofilm laminate exhibited the purple color characteristic of reduced myoglobin throughout the storage period of 12 days. Subsequent brightening occurred on exposure of the meat to air.

Of various packaging materials tested with fresh meat, a laminate of aluminum foil and pliofilm was found to be most effective in retarding spoilage. Because of its low gas permeability, this material was well adapted for packaging with carbon dioxide. In trials using MSAT-80 cellophane and the aluminum foil-pliofilm laminate, keeping time of meat was improved by the incorporation of carbon dioxide within the atmosphere of the packages. Initial exposure of fresh meat to carbon dioxide prior to packaging was demonstrated to be of value in prolonging storage life. The level of gas for such exposure was limited by discoloration that resulted when high concentrations were used.

Cellophane films and waxed paper permitted greatest weight losses of meat packaged with several films and foils; samples wrapped with the other materials evidenced no appreciable loss in weight.

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Consumer Trends in New Food Products for Homemakers[a]

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Some old and some new trends in consumer preferences for processed foods are discussed. The consumers' desire for short times of preparation and ready-to-serve dishes opens up wide new vistas for food processors.

Few tasks could be more challenging to a food technologist than that of analyzing the thinking of the consumer during the postwar period—what she wants and does not want in foods, what chances she will or will not take in feeding her family, what she expects from the food manufacturer. If the task were chemical in nature, we could run an analysis and report precisely. This is not a library study, either because sufficient time has not elapsed for writing an academic account of what has been, and is, going on in this collective mind. Therefore, we must report opinions from heterogeneous sources. Accordingly, this paper is based upon consumer panel tests, information from food manufacturers who have succeeded or failed with new items, articles in miscellaneous publications, and talks with people who have been concerned with feeling the pulse of consumer wants. And of course, there was also personal experience to draw from, even without the opportunity of seancing with 10,000 representative homemakers while they revealed their inner thoughts on foods.

Naturally, we are most interested in observations about which we, as food men, can do something. Only if opinions have potential possibilities for improving our food supply system can this report on consumer thinking have practical value. Knowing the habits and characteristics of consumers is of utmost importance to the food manufacturer, who must select and develop new products accordingly. Conscious of this demand for the utilitarian, I have tried to fathom the thinking of this complex, practical, and highly important consumer of the foods we provide.

Homemakers fall into many different groups. There are the young, inexperienced ones, and the older homemakers who still glory in the artistry of cooking. There are those with no children and those with one or several. Some have tiny, inconvenient kitchens, others have large ones with modern equipment. There are families who must carefully watch their pennies, and those who need not. There are families with physical workers who need three square meals, and those who must count their calories. There is the homemaker who works and cooks at home on the "catch as catch can" basis, compared with the one who spends hours in the kitchen. We must think, however, of a composite homemaker—an average one—for there is no time here for discussing each group's approach to food.

Let us first recognize some of the many conflicting problems facing this homemaker. She must determine the amount of money she can spend, the best food buys, the taste preferences of her family, and the proper diet for sound health. It is a hard job, and she begs the manufacturer to help her. She will go arm in arm with him if he meets her wishes, and she will leave him cold if he fails. She is also in a different state of mind than in 1942. We are in an equinoctial season, not knowing whether we should wear a topcoat or a summer suit. Women are confused and upset because we are not calmly at peace or tensely at war. They are thinking a little too much, perhaps, from day to day, from meal to meal, and expecting anything.

Today, 34% of the family income is spent for food, as compared with 36-40% only a few years ago. Our standard of living has soared, with more income spent on travel, home equipment, furnishings, books, and educational projects, which make for a fuller life. This increases the pressure on the food budget, and has greatly widened the span of income groups who must be, many for the first time, cost-conscious in food buying. The food segment of the dollar is really being squeezed.

The woman is, by custom and necessity, the one who spends the food money and who saves the extra pennies. She must watch each nickel, and no federal permit or a law passed by the legislature can entitle her to double the amount she may spend for any one item. Her food allowance per week may be increased from time to time by great pressure on the wage-earning half of her family, but the husband is rare who blandly says, "I know food is up, here's a 50% increase in your allowance." So, Madame Housewife, without benefit of efficiency expert, must try a new mix or prepared food with three big questions in her mind: Will it do the job? Will the family like it? Will it *save* her money? Here lies a growing challenge to the food industry. A few years ago, before inflation, quality was considered far more important than cost in developing a food item (it was rightly felt then that a good product had a fair chance for success though the price might be a little high). Today, the cost of even basic dietary needs has so increased that even the most quality-minded woman must think of *both* quality and price. Very few of our nation's homemakers can spend as much as they would like to feed their families, and any manufacturer of food products who can give the food-purchasing public a prepared mix or food that reacts well for the cook and which the family will accept, at the lowest possible price, is "in solid" with her. So, to my mind, a big trend today is away from high-priced luxury combinations in foods and toward the purchase of the "mostest for the leastest." That is a bitter pill for the manufacturer who has considered quality the only criterion, but if he uses ingenuity in developing and publishing with every item recipes for new food combinations, wherein the simpler foods can be made into attractive, tasty dishes, he will survive and should prosper.

Shopping habits have been changing, too. It is stated that over 90% of women now shop in person. They want to see what they buy; and the impact of labels and promotional material is greater than ever. More and more items are bought for the week and not the day. Homemakers want help on the use of the common, economical, basic foods for maintaining variety in the family meals. Women still do much impulse buying, good packages and good displays appeal to them. If the performance

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of a new brand is in harmony with the attractive package, an old, established brand may have a serious new competitor. Women continue to want information on how to cook foods perfectly to get the most out of them. They will try new products and new methods, but they have neither the time nor the money for unreasonable experiments or studies for the sake of science—they expect us to do that job for them.

In this country, there are thirty million children under ten years of age. No wonder they are foremost in the thoughts of so many shoppers. They wonder if the foods are good for the children, as well as for the adults. Are highly spiced recipes, developed on adult tastes, the kind youngsters ought to have? Women would like to see a greater consciousness on the part of manufacturers for tuning recipes to the little folks—a viewpoint too often overlooked in using recipes for selling food.

The spade work in many new foods has been done. The age-old superstition that fresh foods are always to be preferred to canned or frozen is rapidly disappearing. The imagination of the housewife has been stimulated by the quality and convenience of frozen juices, prepared vegetables, "brown 'n serve" rolls, and prepared mixes. In earlier years, the pantry shelf held only flour, salt, soda, baking powder, sugar, shortening, and eggs, from which the homemaker laboriously prepared biscuits, griddle cakes, waffles, pie crust, cookies and cakes. Today she has opened her arms and her mind to the labor-saving joy of prepared mixes requiring only the addition of water or milk or eggs. They enable her to produce consistently a better product for the table than she could make, yes, consistently better. This uniformity in results is one major reason for the growing trend toward prepared mixes: They are removing the gambling in cookery.

Also, few housewives today have the time or inclination to spend an hour mixing a cake by the old method when a mix will do it in ⅓ the time. Even in rural areas and towns whose population is under 10,000, the sale of prepared baking mixes, for example, has increased over 10% in the past two years. Who would have thought, a few years ago, that even rural people would go urban so rapidly on this modern trend. Few women have so little to do that they will buy a pound of fresh uncooked shrimp, boil them, remove the black vein, prepare a light cream sauce and then boil long-cooking rice to serve with it. No, the 1951 cook mixes a can of mushroom soup with a package of prepared frozen shrimp, adds a teaspoonful of sherry, cooks up some precooked rice, and in 20 minutes, her dish is ready—and why not? She has had a busy day, she has washed dishes, marketed, made beds, swished the dust mop around, settled children's quarrels, washed their faces a dozen times, dressed and undressed them several times, seen that they got to the dentist, the school party, the movies, or dancing school and at 5:30 P. M., she couldn't tell you her right name if you asked her. But now she must prepare a good dinner for a husband, exhausted from his battle to earn a living. Would anyone question why she wants speedy dishes that can be prepared appetizingly in a hurry and with little effort? So, of course, on her shelf are some cans of meat stew, which can be dumped into a casserole, topped with a prepared biscuit crust for a meat pie. And why, she asks in passing, doesn't some stew manufacturer make a meat stew that looks like it was homemade. "Why is the meat always cubed in nice little half-inch squares?" asked a housewife with whom I talked. "Stews at home are always made with uneven pieces of meat and vegetables. How can I disguise a canned stew when every item in it screams "cut with a machine and measured with a ruler"? And here lies another trend—along with canned foods that offer speed in preparation, women want them to look homemade and not too much like factory goods. She still likes the family to think her dishes were made at home and to enjoy them with that thought in mind. The can opener may be the most important gadget in the kitchen, but the homemaker yearns to put her own seal of individuality on the table dishes.

More women than we think want basic help on the standard foods which we have taken too much for granted for years. No wonder she has gone for the packaged mixes, canned meats, macaroni-and-cheese dinners, baby foods and a score of others which cater to this demand for the pillar items built to save time. Living is becoming more informal. Company dinners, parties for family celebrations, still play a prominent part in our social life, but the formal dinner, with its many courses, is passing, as well as demi-tasse in the living room. Dinners that require maid service and great effort in serving are becoming rare. Party meals are still popular, but they must be handled with dispatch and less effort because bridge, canasta, television, or movies are just around the corner.

What has happened can be summed up by saying that the food manufacturers, processors, distributors, and all other handlers are learning how they can remove many laborious tasks in the kitchen, put on the table better foods in shorter time, and yet maintain the pride of the homemaker in her special privilege of feeding her own family well.

There is a horde of simple little criticisms expressed by women. You may be surprised at the number of women who object to packaged mixes, cereals and so forth, requiring that the entire top of the package be cut off. They like the one with the little eased corner or side flap which can be pressed in to let the contents pour out. When the top is removed, especially with cereals and mixes, a waxed paper covering must be used, they say, to keep the dust or weevils out. Also, certain cans of spices and herbs have, instead of the slide top, a small friction top, which must be pried up each time the seasoning is used. Some women avoid products because of such inconveniences. They also object to mixes with frail inner paper fillers which tear easily when the package is opened. Women are fundamentally neat and tidy, and they appreciate the little, as well as the big, conveniences.

Every attempt made to learn how women feel about cleanliness standards in food manufacturing plants brings in the same overwhelming demand for the strictest sanitation in handling food. Sanitation is the order of the day, and the time may not be far off when a dirty plant operating on unsanitary practices can stay in business only by keeping its doors shut to the public. Some day, the public will really want to know if a restaurant or food plant of any kind is truly clean. A few companies are already winning competitive favor by proving to the consumer that their products are handled from start to finish under kitchen-clean conditions.

Women read, and like, advertising. It is the fuel behind the customer system, and supplies a vast amount of information on food. And in her independent manner, she pays attention to the advertiser and may quickly cast a vote for or against a brand, depending on the soundness of the copy. No political pull can put over a new product or even maintain an old one. The woman can vote by buying as she wishes, and the manufacturer

knows only too well that the cash register is one ballot box that can't be stuffed.

A consumer trend of evergrowing importance is the desire for truthful advertising. Why say in the recipe on the can or in the pamphlet accompanying it . . . "This recipe serves 4" or "Makes 20 biscuits," when many times the can of prepared food makes a good hearty serving for only two or three. When she stretches it meagerly to the four it is supposed to feed, she is annoyed and disappointed. And when the "20 muffins" turn out to be 15 in her baking tins, she suspects she has been "took".

Let us not underrate the intelligence of a woman. You may dress up a package in fancy wrappings, advertise it as the best product every devised in that line, say it is the most wholesome, the most economical, and so on, but you won't get more than a first purchase if you don't give her what you said you would. You would be appalled to read the letters from women about a can or a package of some advertised products. Enough women do read labels and ads to find these ever-present slip-ups. The complaints range from too much liquid in the can with too few vegetables or fruits and unreasonable air space in a packaged product to actual disgust at a big package with a false bottom. Women do not like these merchandising stunts and it is hard to give a satisfactory answer to the "why" of these procedures. A "court of domestic relations" is needed to explain why her chocolates were whitish when she opened them, why a two-inch air space was in her package, why the manufacturer put "meat" or "mushrooms" on the label, but she couldn't find but a whisper of either. She never seems to complain about too much pork in a can of pork and beans, either! She may accept "the floating on a cloud" for her bath salts, the "sun-kissed tint" of her face powder, the "moon-beam softness" of her hand cream, even though she knows in her heart she probably won't get them; but in foods she is a true realist, and when the label or advertising says "meat" or "mushrooms", she expects them there to be eaten and enjoyed.

Women today are reading about food in magazines, newspapers, commercial literature, public service booklets. They are hearing about it on the radio. They watch it being prepared on TV. They are getting answers to their questions by consulting friends, writing manufacturers, talking to the librarians, and listening to sales people. And they are comparing similar products: One automobile with another, one cereal with another. It is no wonder that our people as a whole are grateful for enriched flour and recognize more and more that it was a step forward to automatically improve foods. They like this new approach of so insuring better diets. If rice, for example, reaches a per capita consumption to warrant more enrichment, it is anticipated the public will like this too. There is also reason to feel that they would like to see food manufacturers, and not others, take the lead in these movements.

Confidence in a brand name is the homemaker's salute to the hall mark of our free enterprise society, and she is hurt when her trust in this democratic symbol is misplaced. She feels, too, that a brand name represents years of research and hard work and devotion by the manufacturer to the improvement of a product. A brand has "class" to her, and the food technologist deserves to have her know about the part he played. After all, it is his symbol, too, of a technical contribution far too little recognized today by the consumer. A recent DuPont survey points out, however, that brand loyalty is now in the balance, the impulse of new brands attractively packaged is a growing competitor of old-time brands with established character and popularity. It was reported that even as much as ⅓ of the baby foods and ¼ of coffees were bought on impulse. But those new products must be good and must perform well in the kitchen or they are doomed to failure even after price cutting might have somewhat prolonged their life. A good new brand may also be a stinging stimulus to an old brand which has been just coasting along.

Labels are a form of advertising, and they mean more today to women than ever before. They may not be read as carefully as we would like to have them, but increasing numbers of people want to see on the label the significant information that concerns them. If they are allergic to certain ingredients, they want to be warned by the label. And many who must watch their calories are asking why more labels do not list fuel values, even the total caloric values on the finished recipes on the label. More helpful labels, not necessarily informative for information's sake, are wanted. Naturally, she cares little if a lard contains butylhydroxyanisole, but she is eager to know that this lard stays fresh and sweet for a long time.

It is truly gratifying to find one great advance in the attitude of homemakers toward food. With increasing appreciation, they know that good food and good health are inseparable, and that health and strength are one and the same. They know, too, that we must be individually strong in order that we may be nationally strong. With that conception of food, there must prevail an everlasting challenge to handle it well and use it perfectly.

In closing, may I connect these consumer remarks with one phase of food technology. If this talk has any place at all in our daily work, we should tell homemakers about our profession in a simple, direct way that will interest them. Why should we work so far behind the front lines when the consumers decide so definitely our very destiny? And we can often do this without passing outside the periphery of our own companies and can still further elevate the prestige of their products. We are an important professional force in this country and deserve professional standing among laymen. Let us hasten the recognition of our group for a place with the doctors, lawyers, clergy and others who serve the public. Let us enter the arena of public education. As Theodore Roosevelt said, "Let us try for this achievement, and if we fail, at the worst, while trying greatly, we shall never be with those cold and timid souls who knew neither victory nor defeat."

Quality and Palatabilty of Lamb of Three Different Cross Breeds

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Tests were made to compare the quality of the meat from first and second cross Rambouillet and Columbia lambs and first cross Targhee lambs. Differences in palatability or cooking losses for the roast legs or panbroiled chops were too small to be significant in most cases.

The income from sheep production in Utah has shifted during the past years until under normal conditions the income from the sale of lambs is greater than that from fleeces. These relationships vary considerably, however, when there is a scarcity of wool. The improvement of the meat producing abilities of range sheep is being studied by Utah State Agricultural College *(1)* in which high quality rams are being bred to range ewes. It became of interest, therefore, to study the quality and palatability and the vitamin content of lambs selected from the cross breeds being developed. These lambs have a known nutritive history. Many of the studies on lamb which are reported in the literature have been made on market meat whose nutritive history was unknown.

In this paper the results on the quality and the palatability of lamb produced by breeding range ewes to rams of three different breeds and produced by fattening on the range and in the feed lot will be reported. The thiamine, riboflavin, and niacin content of the lamb will be reported in later papers.

EXPERIMENTAL PROCEDURE

The lambs were selected at random from the large experimental herd of sheep in southern Utah, where they had been raised under good range conditions. First and second cross lambs from Rambouillet ram x grade Rambouillet range ewe (R_1 and R_2) and from Columbia ram x grade Rambouillet range ewe (C_1 and C_2) and first cross lambs from Targhee ram x C_1 ewes (T_1) were studied. The lot of lambs that was taken directly from the range is designated as grass-fat, while the other lot was fed 92 and 97 days for the 1948 and 1949 lambs, respectively, on a grain mixture of dry molasses beet pulp, whole barley or wheat, salt, and steamed bonemeal plus alfalfa hay. The grass-fat lambs were approximately 5½ months old, while the fed lambs were approximately 9 months old.

During the first year four grass-fat lambs of each cross breed and ten fed lambs in each group were studied. The following year eight lambs were used in each group. The carcass grades and weights which show the uniformity of these animals are given in Table 1. The carcasses were aged for 7 days under commercial conditions.

The rib and loin chops were cut 1 inch thick. The chops and legs from the right side of each animal were used in the cooking tests which were carried out under standard procedures without seasoning as described in the manual on Meat and Meat Cookery *(2)*. The legs were roasted at an oven temperature of 325° F. (163° C.) to an internal temperature of 180° F. (82° C.), medium done. The chops were panbroiled at a temperature of 230° to 268° F. (110° to 130° C.) until medium done which required 30 minutes when 6 chops were cooked in the same pan.

Tests for tenderness were made on 3 samples from each of 2 raw chops and on 5 samples from the roasted leg of each animal on the Warner-Bratzler shearing machine. Uniform samples of meat were cut with a cylinder 1 inch in diameter. A panel of 7 judges scored the cooked samples for tenderness, texture, juiciness, and flavor of fat and of lean. The samples of meat were judged by the paired-eating method of Cover *(3)* and were also scored by a scale of 1 to 5 with 5 being highest score.

TABLE 1
Grade and weight of lamb

Lamb	Number of lambs	Carcass grade	Carcass weight
			lbs.
Grass-fat lambs, 1948			
Columbia, first cross (C_1)	4	Good	48-57
Rambouillet, first cross (R_1)	4	Good	44-48
Fed lambs, 1948	3	Good	52-57
Columbia, first cross (C_1)	7	Commercial	43-52
Rambouillet, first cross (R_1)	2	Good	49-52
	8	Commercial	43-51
Grass-fat lambs, 1949			
Columbia, second cross (C_2)	2	Good	44-45
	5	Choice	44-54
	1	Prime	52
Rambouillet, second cross (R_2)	4	Good	45-48
	4	Choice	49-53
Targhee, first cross (T_1)	2	Good	41-44
	5	Choice	47-52
	1	Prime	53
Fed lambs, 1949			
Columbia, second cross (C_2)	3	Good	46-49
	5	Commercial	44-51
Rambouillet, second cross (R_2)	3	Good	50-53
	5	Commercial	44-49
Targhee, first cross (T_1)	6	Good	44-53
	2	Commercial	42-49

RESULTS

The data on the palatability scores for the comparison of the C_1 and R_1 lambs are summarized in Table 2. Although average scores indicated that chops of the R_1 grass-fat lambs were slightly more tender and rated slightly higher for texture, and flavor of lean and of fat than the C_1 chops, the differences were too small to be significant. Differences between the cooked legs of these lambs were also not significant.

The differences in shearing force between the C_1 and R_1 raw chops from the fed lambs were significant, indicating that the R_1 chops were more tender. Tests on the cooked legs from the fed lambs did not show any significant differences. The percent of cooking losses for these roasts was greater for the fed lambs than for the grass-fat lambs. The differences in cooking losses between either lots of R_1 and C_1 roasts were not significant.

There was little variation in the force required to shear the cooked legs of the C_2, R_2, and T_1, grass-fat or fed lambs. These differences were too small to be signifi-

TABLE 2

Average palatability scores with average shear force values of 1948 lambs

Variables	No. of lambs	Chops				Legs			
		Paired tests[a]		Numerical scores[b]		Paired tests[a]		Numerical scores[b]	
		C_1	R_1	C_1	R_1	C_1	R_1	C_1	R_1
Grass-fat lambs, 1948									
Shear force, lbs.	4	9.7[c]	7.8[c]	....	....	8.0	7.4	....	....
Palatability score									
Tenderness	4	4.9	6.9	3.8	4.2	6.9	10.1	3.9	4.2
Texture	4	4.5	7.2	3.5	3.9	7.6	9.4	3.8	3.9
Flavor of lean	4	5.4	6.4	4.0	4.1	9.5	7.5	4.2	4.1
Flavor of fat	4	5.4	6.1	3.8	3.9	....	....	....	....
Juiciness	4	6.6	4.9	4.0	3.9	11.5	5.5	4.1	3.7
Cooking losses, %	4	....	....	20.1	20.5	....	....	22.0	25.0
Fed lambs, 1948									
Shear force, lbs.	10	10.8[c]	8.4[c]	....	....	10.9	11.7	....	....
Palatability score									
Tenderness	10	6.3	5.3	3.6	3.5	9.2	8.1	3.9	3.8
Texture	10	6.5	5.1	3.7	3.5	9.8	7.6	3.8	3.6
Flavor of lean	10	5.4	6.2	4.1	4.2	8.5	8.8	4.1	4.1
Flavor of fat	10	6.3	5.4	4.0	3.9	....	....	....	....
Juiciness	10	6.2	5.4	4.0	3.9	8.8	8.4	3.8	3.7
Cooking losses, %	10	....	....	24.8	24.1	....	....	33.5	31.3

[a] High score indicates best under palatability scores.
[b] Maximum score for any factor, 5.
[c] Raw chops, all other values on cooked meat.
[d] Significant difference (P equals 0.05).

cant (Table 3). However, in the paired and scored tests of the cooked leg from the grass-fat lambs, tenderness and juiciness showed significant differences. The Targhee crossbred lambs scored highest, indicating that the meat was more tender. Shear force readings also indicated that the T_1 legs were more tender although values were not significantly greater. In all other tests on either group of lambs differences were not significant.

Fairly close agreement was noted between the scores for tenderness by the shearing machine and the panel of judges, the linear correlation coefficient being -0.564 for the 1948 tests and -0.709 for the 1949 tests. Both of these figures were highly significant.

Differences between methods of feeding were highly significant for tenderness of the roast legs of the combined C_1 and R_1 lambs, as measured by shear force, the grass-fat tissues being more tender. The effect of feeding on the tenderness of the C_2, R_2, and T_1 tissues was insignificant.

Cooking losses were similar for either lot of C_2, R_2, or T_1 roasts.

SUMMARY

Panbroiled chops and roasted legs of first cross Rambouillet and Columbia grass-fat and fed lambs were compared for quality and palatability. The raw chops from the R_1 fed lambs were significantly more tender as measured by shearing force than those from the C_1 fed lambs. The scores by the panel of judges for tenderness, texture, flavor of lean and of fat, and juiciness for the cooked legs and chops from the grass-fat or fed C_1 and R_1 lambs were similar, the differences being too small to be significant.

In a study of the palatability of roast legs of second cross Rambouillet and Columbia and first cross Targhee

TABLE 3

Average palatability scores with average shear force values of 1949 lambs

Variables	No. of lambs	Legs							
		Paired tests[d]				Numerical score[e]			
		C_2	R_2	T_1	L.S.D.,[f] P=0.05	C_2	R_2	T_1	L.S.D.,[f] P=0.05
Grass-fat lambs, 1949									
Shear force, lbs.	8	8.1	8.0	7.0	N.S.	....	....	....	....
Palatability scores									
Tenderness	8	5.0	7.1	8.8	2.8	3.7	3.9	4.1	0.23
Texture	8	6.3	6.2	8.4	N.S.	3.6	3.6	3.7	N.S.
Flavor of lean	8	6.4	6.8	7.6	N.S.	4.1	4.2	4.2	N.S.
Flavor of fat	8	6.1	6.1	8.7	N.S.	3.7	3.8	3.9	N.S.
Juiciness	8	5.7	6.5	8.7	2.0	3.7	3.8	3.9	0.13
Cooking losses, %	8	....	....	....	....	28.8	28.4	29.0	N.S.
Fed lambs, 1949									
Shear force, lbs.	8	8.1	8.2	8.8	N.S.	....	....	....	....
Palatability scores									
Tenderness	8	7.0	6.8	7.3	N.S.	3.9	3.8	3.9	N.S.
Texture	8	7.2	6.6	7.0	N.S.	3.7	3.7	3.7	N.S.
Flavor of lean	8	6.6	7.0	7.3	N.S.	4.1	4.1	4.1	N.S.
Flavor of fat	8	7.0	7.5	6.5	N.S.	3.8	3.9	3.7	N.S.
Juiciness	8	6.7	6.7	7.7	N.S.	3.8	3.7	3.8	N.S.
Cooking losses, %	8	....	....	....	....	29.3	28.9	28.4	N.S.

[d] High score indicates best under palatability score.
[e] Maximum score for any factor, 5.
[f] Least significant difference. "N.S." indicates "not significant."

grass-fat and fed lambs, differences were not significant except in the paired and scored tests for the tenderness and juiciness of the legs from the grass-fat lambs. The Targhee crossbred lambs scored significantly higher on these two points. Shear force values also indicated that the Targhee legs were slightly more tender.

The legs of the grass-fat C_1 and R_1 lambs were significantly more tender than those of the fed lambs. This was not true, however, for the C_2, R_2, and T_1 lambs.

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Engineering Concepts of Continuous Processing

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The three basic concepts fundamental to the design and operation of a continuous system are discussed and the relative merits of continuous and batch processing are reported. The advantages of proper continuous processing are pointed out.

There are, in my opinion, only three basic engineering concepts which are fundamental to the design and operation of a continuous system. These are as follows:

1. **Continuous flow.** This is the salient feature of the continuous operation. This is almost too simple to mention but from it follows that flow arrangements should be designed first, then the equipment designed for the ideal flow methods.

And actually, how are plants generally "laid out"? By finding standard pieces of equipment and tying them together with transfer conveyors, piping, etc. The conveying system is generally adapted to the machinery which is all right if the machinery itself is basically designed to be used with continuous flow conveyors, etc., but machinery is generally "adapted" to such devices, not specifically developed to be used with them. An exception might be cited of the close-coupled packing lines, which are really a beautifully conceived and executed continuous process, and quite recent even in such an advanced field of mechanization as packaging.

If asked about it, we would all say that one should develop a plant layout by first determining the best flow system, not forgetting probable future growth, then designing equipment and lastly fitting a building around the process, and we all know that the exact reverse of this is the normal procedure.

The automobile industry really appreciates and applies this simple concept. They have special machines developed to operate at the production line and, of course, everything is predicated on the complete use of the production line concept. Many food industries and chemical plants do not appreciate this very basic part of continuous processing because the materials they handle are easily transported, as for instance by piping. Therefore, they are frequently led into a poor development of a continuous operation.

2. **"Steady-state conditions."** Another self-evident characteristic is that operations must be repetitive under substantially constant conditions. For processing work, this is our old friend "steady-state conditions." This concept is so elementary that I am virtually at a loss to find reason to amplify it further.

3. **Control.** A third feature of continuous operation is control. This generally involves mechanisms for handling solids, valves for handling liquids, and instruments to do the controlling of the operation, and to supply most of the operating headaches of a process.

Most plants, probably even the ones you are associated with, do not take care of instruments. Except in the oil industry where continuous processing and consequent instrumentation are highly developed, I have never seen a group of instruments all of which were in good operating shape. Generally, in food plants, they are not even mounted decently. Practically never is there an instrument maintenance man available, and never a spare instrument! There must be some exceptions but I have not seen them. In any event, this points up a dangerous spot in continuous processing and one not to be overlooked.

Certainly, these three engineering concepts concerning continuous processing are simple and, practically speaking, self-evident. It might be helpful, however, to note other factors and conditions and to look at continuous processing from various points of view, and in so doing we will develop factors which I believe are consequences of continuous processing; they are not basic concepts.

One very useful approach would be to consider the question as to where continuous processing is most advantageously applied.

I believe that from the first concept of continuous flow it follows that wherever a considerable amount of material is to be handled and wherever labor costs are a large factor, continuous processing is indicated. The anomaly here is that the handling of liquids and processing them continuously has undoubtedly outstripped the continuous processing of solids, except on certain very simple applications. The reason is not hard to find in the earlier availability of measuring and controlling devices for liquids and the ease of handling them continuously. Actually, continuous processing does not save a great deal of money because liquids are so easy to handle in any event. On the other hand, solids are more difficult to manage. Except for certain very straightforward conveying problems, they call for

greater ingenuity in the development of special handling devices. Engineers have been greatly handicapped by not having available satisfactory automatic measuring and controlling devices. The automobile industry, where the problems are strictly mechanical, and certain of the extractive industries, which are also essentially mechanical in nature, have developed satisfactory continuous processing operations in handling solids.

Continuous processing in the cooking phase of the food industry has not gone as far as it might because the great bulk of labor costs, and hence the possibilities for saving, used to be and, in many cases, still are in the packaging area.

In going through candy plants, I have been much impressed to note as few as four men on the top floor mixing the sugar, water and other ingredients. Descending to the enrobing floor, one will find forty people and then lower down at the packaging rooms something like four hundred. Obviously, changing an operation from a batch weighing, measuring, and cooking system to a continuous one is not going to eliminate a great amount of labor, but almost anything done in the packaging room to change the efficiency even to a small extent, would affect the gross amount of labor and gross costs very heavily. Since there have been such outstanding opportunities for saving in this field and since machinery was available and was being rapidly improved which competition forced one to buy, it has developed that practically all of the money that a firm has to invest is employable under very advantageous and even necessary conditions in improving their packaging operations.

Furthermore, old processing equipment of a batch nature can be kept going with a rather small maintenance cost, but old packaging machines have a very high maintenance cost.

CONTINUOUS PROCESSING AND TIME-TEMPERATURE EFFECTS

From the "chemical processing" point of view, an ideal use of continuous processing is an operation where there is a large heat release or heat absorption and where the time factor involved is either of economic or quality importance.

For instance, such large users of heat as evaporators, stills, and boilers are all continuous unless they are very small in capacity. We can find various other examples.

In the food industry, an outstanding example is the flash pasteurization of milk. The elements of continuous flow, small quantity of hold-up, rapid heating and cooling, countercurrent operation, good control, and recorded conditions are all present and are typical of many excellent applications of continuous processing. The final result, an excellent product, is also typical.

There is one batch operation which I have had occasion to look into that appears to me to cry out for a continuous technique, Lorol manufacture. This is the preparation of a cocoanut fatty acid-based detergent. The present operation is batch-reacting the hydrogenated cocoanut oil with sodium and an alcohol, then reacting the intermediate product with water during a 10-minute cycle of very high heat liberation and 2 hours of "down time". While it is obvious to any chemist that the feeding of the sodium compound into water would be done "continuously" over the 10-minute cycle, I submit that if the available 2 hours were used, some of the results which flow from continuous techniques would be very apparent: condensing equipment $\frac{1}{12}$ as large as "batch", less building space required, and lower peak loads on services.

There is another consequence, less surface area of metal per unit of thruput. This generally results in less contamination from corrosion. It reduces markedly the quantity of material required for constructing equipment since not only does the area of equipment surface go down but also the thickness required is reduced due to the smaller size of the vessels. Frequently, the equipment reduces to an assemblage of tubing. For high pressure operations, these are definite corollary advantages.

One small continuous operation was developed largely to obtain a product of lighter color. The operation is reasonably complicated as it includes drying, catalyst preparation, proportioning of ingredients, chemical reaction, stripping, gravity separation, and then centrifugation. The product turned out to be more uniform and of better quality in all respects than that previously produced by the batch method. The plant has been comparatively easy to run and has operated at a rate of 500 lbs. per hour or 3,000,000 lbs. per year with ease. The installed cost of the equipment would be $80,000 in today's market and the building space no more than 600 square feet.

Now, there are some reasons why continuous processing is not more used. Frankly, the main reason it is not used as often as it should be is that managements are "conservative".

Another and very important reason is that practically nothing that a chemist does in a laboratory during a development is continuous. The laboratory worker obtains his results using a batch method, then he goes through the development steps using a batch method and when demand for the product develops, the management will not spend time or money to redevelop the operation on a continuous basis, and at that one must admit they would usually be right.

There are some operations where experience indicates that batch operation is best, for instance, the mixing of small amounts of material into large amounts of powder.

Continuous processes are considered to be less flexible than a batch operation. It is undoubtedly true that a tank with an agitator can be used for more different types of work than can a tubular reactor. On the other hand, one can generally vary time, temperature and even thruput over a wider range with continuous equipment than with batch equipment.

A very real limitation follows from the fact that even very small continuous equipment has a very large capacity over a year's time. A 100 lbs. per hour is practically 250,000 lbs. per year on a single shift basis. It does not have to be run every day, but even though it may be quite flexible in operation, as pointed out previously, it is nearly always specialized and not of as much general use as certain simple batch units.

A continuous process is not desirable where too many things may go wrong. One illustration comes from the mechanical field but is easily understood. In making twisted wire, ninety-six strand, all continuously on one machine, any spool which broke

or ran out of wire caused a shutdown on the machine, and with ninety-six strands the stoppage was not only very frequent but was practically speaking, always.

After having told me this story, the manager of the firm expressed a desire to run two machines in series and still wished to do so at a point five feet away from where the dead monstrosity lay. At the time, they had four operating heads on a wire process being handled by one man and one of these was always down. Therefore, they had three-quarters efficiency with one man operation. If they arranged two sets of two in series which is what they wished to do, the plain arithmetic says that of the four heads involved in the two sets of two, one would always be down, but this would affect one whole set and, therefore, there would be only one-half efficiency on use of machinery. This does not take into account the fine reasoning as to what would happen if and when one head in each of the pairs was broken down.

Another fundamental reason for not having more continuous operations was mentioned earlier when it was pointed out that the processing division of candy manufacturing generally required very little labor as contrasted with the packaging end. This is not true on certain disassembly operations in the meat packing and vegetable handling industry, and such operations are now almost invariably continuous. These are very simple applications of continuous processing, albeit the machines are human hands in practically all instances.

In general, those industrial firms which have worked out continuous processes have done so after having many years of reasonably successful batch cooking operations and even then only for the following reasons:

a. One man in the organization believes the quality can be improved and it is desirable to do so.

b. Some executive with vision believes that in the long run the firm will have to or should do a real operation essentially at the primary manufacturing point, as well as at packaging and storage, and, therefore, invests money intelligently in preliminary work. There are firms which should do this but do not. A man doing an intelligent executive job for the firm should have studies and plans ready to replace obsolete equipment with a better process and not just "modern equipment". Further, in most large plants there is at least the reasonable likelihood of having a new plant put up somewhere and the development work for the best possible process should be done and should be available long before the necessity for the new plant or change in equipment occurs. Then, there is the danger from fire. An executive should always be ready to rebuild or replace, preferable in better shape than previously.

c. Somebody is spellbound by the idea that continuous operation is desirable and (generally) misapplies it.

From certain developments in potato chip frying, we can observe another desirable factor which is usually a corollary of any continuous operation; relatively small quantities of material are employed at any one time and in relation to the thruput. For instance, some potato chip frying equipment produces 300 lbs. of product per hour, using 1,500 lbs. of hot fat, whereas better designed equipment for making French fried potatoes handles 3,000 lbs. per hour of potatoes with only 3,000 lbs. of fat under heat. These are not directly comparable operations but the factor of 5 to 1 can be cut in half and account for the different type of product cooked and still be very attractive.

Putting these factors together, there is a saving of two-thirds in the quantity of fat under heat at any one time for a given thruput of potatoes. Mr. A. A. Schaal, now heading the Good Housekeeping Institute, was one of the first to realize this and to see that the results would be a much higher quality product at a lower cost. The quality improvement came from a very small amount of fat being present and being used up rapidly, becoming part of the product; hence, it was always relatively fresh and the shelf life of the product was greatly extended. Naturally, the cost of the operation was low as no fat matter had to be discarded as contrasted with the better run older style units where the batch was discarded once a week.

If you are going to consider a continuous process, the following analytical approach is suggested:

1. Define the objective precisely. In most instances, the main points normally are to produce a specific material with specific characteristics at a lower cost and with improved quality as compared to existing operations. These items should be made quantitative and desired changes and specific characteristics noted.
2. Study the over-all process, considering existing processes, their good and bad points, and convincing one's self that a continuous process is (or is not) desirable. In many instances, this involves doing a preliminary, careful design of an alternate batch process. Involved will be considerations of quality effect, cost effect, and of the time factor for accomplishment. Experimental work for evaluation of ideas must be included as well as the checking over of the "concepts" put forth by this paper.
3. Express the result of the study contemplated above under 2 as a process flow sheet, giving quantities, physical characteristics of materials and operating conditions and equipment specifications desired at each point.
4. Analyze or better check the flow sheet from all possible points of view, trying to appraise the necessity for each step, the desired characteristics said steps impart to the final saleable product, the possibility of obtaining each result by alternate methods, and the opportunity to combine operations.
5. Reach your conclusions and write a report.

In summary, there are three simple, basic concepts on which continuous processing rests. These are continuous flow, repetitive operations (chemically, "steady-state" conditions), and satisfactory control.

The idea is simple. The problems arise with the devices necessary to carry out the operation.

There are some corollary factors or results which flow from continuous operation: smaller equipment, less building space, lower peak loads on services, less metal required, less corrosion effect, and less quantity of materials being handled.

Generally, there will result a more uniform product, a better product because of ideal time-temperature conditions, and a lower operating cost.

The Use of Modifiers in Chocolate to Retard Fat Bloom[a,b]

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The effect of the addition of modifiers as fat bloom retardants has been investigated and particularly promising results have been obtained where approximately 1% of a mixture of sorbitan monostearate and poly-oxyethylene (20) sorbitan monostearate was added to chocolate. Commercial scale trial runs have been conducted which indicate that the shelf life of the modified chocolate is considerably increased over a similar unmodified product.

In 1947 a study of the behavior of chocolate with particular reference to the problem of fat bloom was started at Lehigh University. The addition of surface active agents to chocolate to achieve this purpose was considered in order, since the existing standards already provided for the inclusion of some "emulsifiers," such as lecithin and monoglycerides. These agents are generally added for viscosity control purposes, although claims have been made that they are useful in retarding chocolate fat bloom.

Chocolate was and is tempered by rule of thumb. To observe the effect of an added material on fat bloom, it was necessary to provide a standard of comparison without the added material. It quickly became apparent that a procedure must be developed that would provide reproducible standard or control samples. It was then decided that it would be necessary to study the tempering problem and to evolve a suitable reproducible procedure.

DEVELOPMENT OF TEMPERING METHODS

Two methods of tempering are known to be possible: 1, to hold the chocolate at a given temperature for a relatively long time, this temperature being close to the application temperature; and 2, to hold the chocolate for a relatively short length of time at a lower temperature to establish temper and then raise it to a suitable application temperature. Both of these methods have been developed to the extent necessary to produce uniform results.

Equipment was set up whereby eight stainless steel 400-ml. bakers could be heated in a water bath and slowly stirred simultaneously. Detailed studies with this apparatus had shown that the tempering of chocolate is a function of both the temperature and time, and that chocolate may be over-tempered and under-tempered. Data observed on a dark sweet chocolate (Hershey-Dauphin) are presented in Figure 1. The area in this figure is divided into three parts. As long as the chocolate is in area A, it is under-tempered. Temper may be achieved by cooling the chocolate to a lower temperature or by holding it at this temperature for a longer time, provided the temperature is not too high. Chocolate in the shaded area designated with B is in temper and will give the best results possible for this specific coating. If the holding time is exceeded or if the temperature is reduced too far, the chocolate may go into area G, where it is over-tempered. Chocolate coatings containing both a higher and a lower liquor content were tested and the curves were found to be identical.

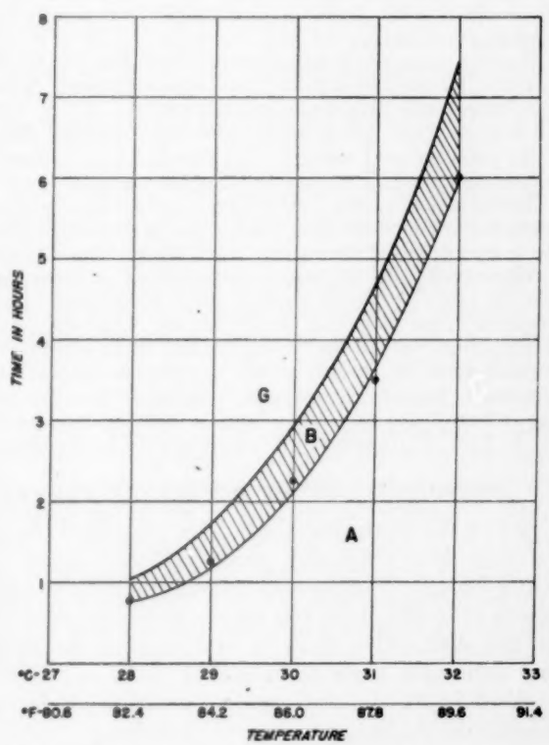

Figure 1. Graph showing effect of time-tempering conditions on temper with area of good temper B, over-temper area G, and under-temper area A.

The actual tempering procedure used for the first method is as follows:

The chocolate is melted with stirring at approximately 10 r.p.m. at a temperature of 122° F. (50° C.) for 1 hour. It is then cooled, over a one hour period, to the tempering temperature. During this cooling operation the chocolate is brought to 91.4° F. (33° C.) within the first 45 minutes with the remainder of the cooling being done during the last 15 minutes. This is done to prevent any appreciable tempering taking place before we are

[a] This work was supported in part by the Research Committee of the Pennsylvania Manufacturing Confectioners Association.

[b] Presented at the Eleventh Annual Meeting of the IFT, New York, N. Y., June 19, 1951.

ready to begin the run. While the chocolate is maintained at this temperature (within ± 0.1° F.) by means of a thermostatically controlled constant temperature bath, samples are withdrawn at various intervals. For example, at 88° F. (31° C.) samples are cast at the end of 2, 2.5, 3, 3.5, 4, 4.5, 4.75 and 5 hours. This procedure insures production of a sample in optimum temper.

Actually, the second method is a modification of the first one. In this method of tempering, the chocolate is taken to a lower temperature than in method 1 where temper is attained more rapidly. As soon as temper is reached, the chocolate is raised to a holding temperature of 87° F. (30.5° C.).

Water for the tempering bath was supplied from a constant temperature bath fitted with a cooling coil and two thermostats. One thermostat was set so that a temperature of 112° F. (50° C.) could be maintained in the tempering bath and one was set so that a temperature of 78.8° F. (26° C.) could be maintained in the tempering bath. A second tempering bath set at 86° F. (30° C.) was also connected in the system.

A cooling tower for cooling the chocolate after tempering was also constructed. The tower was so constructed that 39 minutes were required for a chocolate sample to make one pass. Air was supplied to the tower by means of a blower with the intake air passing over ice so that the tower at the cold end was 48° F. (9° C.) and at the warm end 59° F. (15° C.). The flow of air was directed so that it was counter-current to the movement of the chocolate.

The flow of water to the tempering bath was first controlled so that a constant level in the bath was maintained. The constant temperature bath was connected with the 112° F. (50° C.) thermostat. Then 300 g. of chocolate were weighed into each of the stainless steel beakers. The samples were agitated until completely melted. This occurred in approximately 1 hour.

The chocolate samples were tempered as follows: The constant temperature bath was disconnected and the cold water to the cooling coil was turned on. The cooling water was set at a predetermined rate so that a temperature of approximately 78.8° F. (26° C.) was reached in about 40 minutes. This rate was used in the tempering of all samples. After the tempering bath reached 78.8° F. (26° C.) in the case of standard chocolate, the cold water was turned off and the temperature was held for 5 minutes. After this time water from the 95° F. (35° C.) bath was admitted to the system until a holding temperature of 87° F. (30.5° C.) was reached and maintained by the thermostat.

DETERMINATION OF DEGREE OF TEMPER

While the work described above permitted the establishment of a tempering procedure that would assure that a known chocolate was in temper, there was still no means of determining the degree of temper of a sample of chocolate, other than to cast bars of the chocolate and determine their relative shelf lives. Studies have resulted in the development of two methods for determining the degree of temper of chocolate.

The first of these requires the casting of a bar of chocolate of fixed dimensions, which is then cooled and stored under specific conditions. The conditioned bar is supported at either end in a frame and is struck and fractured by a free swinging pendulum. The amount of force absorbed in breaking the bar is indicated by the difference in the length of swing of the pendulum without any bar being present and with the test bar. The major objection to this test is that the test may not be run until the bar has been conditioned for several hours. For this reason the method cannot be used for plant control.

More recently, a second method has been devised wherein the rate of heat evolution during a modified cooling curve is used as an indication of the degree of temper. This method has been discussed in a preceding paper *(1)*.

Other means of tempering and determining degree of temper have been proposed. These include the use of ultrasonics *(3)* and the weight picked up by a small metal piece when immersed in the chocolate *(2)*. In addition, it may be possible to determine the degree of temper by di-electric or dipole moment measurements or by X-ray defraction.

FAT BLOOM STABILITY DETERMINATION

In evaluating the efficiency of a fat bloom-retardant additive, it was necessary to develop a uniform test method. It was known that fat bloom occurred on long storage of chocolate at room temperature and that it occurred more rapidly if the pieces were subjected to heat and then subsequently cooled. The nature of fat bloom has been studied at Lehigh University and this work was the subject of a prior paper *(4)*.

From the above considerations it was apparent that the test method should employ a combination of high and low temperatures. After trying several alternative time-temperature cycles, a cycle of 24 hours at 90° F. (32° C.) and 24 hours at 70° F. (21° C.) has been adopted.

Very good correlation of accelerated tests, such as these, with long time storage tests has been indicated in tests with hand dipped, dark, sweet chocolate-coated pieces, though this single test cannot be considered as establishing a relationship. In the test mentioned, hand-dipped pieces coated on various types of centers were subjected to accelerated aging tests as well as stored in a retail store under normal conditions of the Thanksgiving and Christmas holidays for 2 to 3 months.

EXPERIMENTAL DATA ON VARIOUS MODIFIERS

The initial phase of the investigation centered on the addition of a single additive. In general, the procedure was to melt the chocolate at 110° to 120° F. (43° to 49° C.), stir in the required amount of additive, temper according to the first system described previously, and then subject the sample to accelerated aging tests. The sample was compared with a standard subjected to the same conditions. The results are presented in Table 1.

TABLE 1

Fat bloom data on single component additions of chocolate

Modifier	Protection	Modifier	Protection
Lecithin	Poor	Nacconol NRSF	Poor
G-949	Poor	Propylene glycol monosterate	Poor
Span 65	Poor	Propylene glycol monolaurate	Fair
Tween 61	Fair	Glyceryl stearate	Poor
Tween 20	Fair	Glyceryl oleate	Poor
Tween 60	Fair	Glyceryl oleo-stearate	Fair
Myrj 45	Poor	Glycawax S-932	Fair
Tween 85	Poor	Poly-oxyethylene stearate S-1042	Poor
Tween 65	Poor	Propylene glycol monomyristate	Fair −
Span 20	Fair	Propylene glycol monopalmitate	Fair +
Span 60	Good	Carboxy-methyl cellulose	Fair +
Span 80	Poor		
Span 85	Poor		
Glyceryl monostearate (100%)	Poor		
Myverol 18-85	Fair −		
Nacconol NR	Poor		

Of the samples tested the most satisfactory ones were those containing Span 60, Span 62 and Tween 61.[c]

Since it is known that blends of emulsifiers are sometimes more effective than the single material, blends of two or more materials were tried. The same method of addition of the agent was employed and both types of tempering methods were employed. The results are indicated in Table 2. The most promising blends were

TABLE 2

Fat bloom data on blends of materials added to chocolate

Modifier	Protection
Span 60 and Tween 60, 80 to 20	Good
Span 60 and Tween 60, 60 to 40	Excellent
Span 60 and Tween 60, 50 to 50	Excellent
Span 60 and Tween 60, 40 to 60	Good
Span 60 and Tween 60, 20 to 80	Poor
Span 20 and Tween 20, 75 to 25	Fair
Span 20 and Tween 20, 50 to 50	Fair
Span 20 and Tween 20, 25 to 75	Poor
Span 60 and Tween 80, 60 to 40	Good +
Span 62 and Tween 40, 70 to 30	Poor
Span 80 and Tween 80, 60 to 40	Poor
Span 65 and Tween 65, 15 to 85	Good +
Span 65 and Tween 60, 45 to 55	Good
Span 60 and Tween 65, 30 to 70	Fair
Span 40 and Tween 40, 75 to 25	Fair
Span 40 and Tween 60, 70 to 30	Poor
100% Glyceryl monostearate and Tween 60, 60 to 40	Fair
Myverol 18-85 and Tween 60, 60 to 40	Fair −
Span 60 and Propylene glycol monolaurate, 50 to 50	Good
Tween 80 and Propylene glycol monolaurate, 50 to 50	Fair
Span 85 and Propylene glycol monolaurate, 50 to 50	Fair
Tween 85 and Propylene glycol monolaurate, 50 to 50	Fair
Span 20 and Propylene glycol monolaurate, 50 to 50	Fair
Tween 20 and Propylene glycol monolaurate, 50 to 50	Fair
Tween 60 and Propylene glycol monolaurate, 50 to 50	Poor
Tween 61 and Propylene glycol monolaurate, 50 to 50	Poor
G-2145 and Propylene glycol monolaurate, 50 to 50	Poor
Carboxy-methyl cellulose and Propylene glycol monolaurate, 50 to 50	Fair

those of Span 60 and Tween 60 and the optimum ratio appeared to be either 60 to 40 or 50 to 50 of Span 60-Tween 60.

In adding surface active agents to chocolate coatings, it was found that the tempering procedure used for the unmodified coating would not necessarily produce optimum temper in the case of the modified coating. In the case of the first method of tempering described above, it was found that depending upon the modifier, the time required at a given temperature to produce optimum temper might have to be lengthened or shortened. Similarly, in using the second method of tempering, it was found necessary to raise or lower the tempering temperature to produce optimum temper. In evaluating the various emulsifiers, care was taken to insure the testing of properly tempered samples and to compare them with a properly tempered standard.

In the preliminary evaluation work, the surface active agents were added to a dark, sweet, lecithin-free chocolate coating. In order to test the effect of a 60-40 addition of Span 60 and Tween 60 on other chocolates, 1% additions were made to straight chocolate liquor and to various other chocolates ranging in fat content from 31.7% to 36.6% and in lecithin content from 0.0% to 0.22%. In every case the addition of the 60-40 mixture of Span 60 and Tween 60 improved the bloom resistance of the chocolate. These results may be found in Table 3.

As a part of the early evaluation of Span 60-Tween 60 additions, vanilla cream, coconut cream, and nut square centers were hand-dipped with chocolate coating containing Span 60-Tween 60 in ratios of 40 to 60, 50 to 50 and 60 to 40. Accelerated and long time storage tests on the pieces showed that each of the emulsifier additions retarded bloom formation, but apparently the 60 to 40 combination afforded the best protection.

SIDE EFFECTS

A thorough study of the viscosity effect has been made with and without lecithin on different types of chocolate before and after tempering. In addition to the effect of 1% Span 60-Tween 60, 60 to 40 additions to the viscosity of dark, sweet chocolate coating, the effect of this addition on various chocolates of different fat and lecithin contents was also determined. These data are presented in Table 4. It will be noted that in most cases the addition of emulsifiers changed the viscosity only slightly. Where no lecithin or only a small proportion was present, the above addition usually caused a slight decrease in viscosity. However, in the case of chocolate of very high initial viscosity as in the case of Coating E, the modifier apparently caused a sharp reduction in viscosity. As the lecithin content is increased to near the maximum, an addition of emulsifiers usually causes a

[c] Span and Tween are registered trade marks of the Atlas Powder Company.

TABLE 3

Fat bloom data on various types of chocolate with and without lecithin

Coating	Ratio of liquor to sugar	Fat	Lecithin	Modifier	Concentration	Appearance 144 hours of storage[d]
		%	%		%	
A	1:1	33.8	0.0937	Span 60 and Tween 60, 60 to 40	1	Good
A	1:1	33.8	0.0937	None	....	Very poor
B	1:1	33.7	0.22	Span 60 and Tween 60, 60 to 40	1	Good +
B	1:1	33.7	0.22	None	....	Good −
C	1:1	33.5	0.0937	Span 60 and Tween 60, 60 to 40	1	Good
C	1:1	33.5	0.0937	None	....	Fair
D	1:1	31.7	0.22	Span 60 and Tween 60, 60 to 40	1	Good
D	1:1	31.7	0.22	None	....	Very poor
E	1:1.066	35.3	0.0	Span 60 and Tween 60, 60 to 40	1	Good
E	1:1.066	35.3	0.0	None	....	Poor
F	1:1.066	36.6	0.22	Span 60 and Tween 60, 60 to 40	1	Good +
F	1:1.066	36.6	0.22	None	....	Fair
G	1:1	35.0	0.22	Span 60 and Tween 60, 60 to 40	1	Good +
G	1:1	35.0	0.22	None	....	Very poor
H	1:0.933	34.4	0.22	Span 60 and Tween 60, 60 to 40	1	Good +
H	1:0.933	34.4	0.22	None	....	Fair

[d] Storage temperature alternating between 15° and 34° C.

TABLE 4

Viscosity effect of Span 60 and Tween 60 in 60 to 40 additions to chocolate

Coating	Ratio of liquor to sugar	Fat	Lecithin	Modifier Concentration	Viscosity at 120° F.
		%	%	%	cp.
A	1:1	33.8	0.0937	1	21,000
A	1:1	33.8	0.0937	0	22,500
B	1:1	33.7	0.22	1	16,800
B	1:1	33.7	0.22	0	13,000
C	1:1	33.5	0.0937	1	19,000
C	1:1	33.5	0.0937	0	16,000
D	1:1	31.7	0.22	1	40,000
D	1:1	31.7	0.22	0	46,000
E	1:1.066	35.3	0.0	1	24,500
E	1:1.066	35.3	0.0	0	92,000
F	1:1.066	36.6	0.22	1	20,000
F	1:1.066	36.6	0.22	0	20,000
G	1:1	35.0	0.22	1	21,500
G	1:1	35.0	0.22	0	22,500
H	1:0.933	34.4	0.22	1	17,000
H	1:0.933	34.4	0.22	0	12,900

slight viscosity increase. Apparently the emulsifier can be used with most chocolate coatings with only slight changes in formulation required to produce the desired viscosity.

In considering the question of viscosity, we have also investigated the effect of the addition of Span 60 and Tween 60 on the viscosity during and after tempering. Figure 2 illustrates these effects. Where the samples

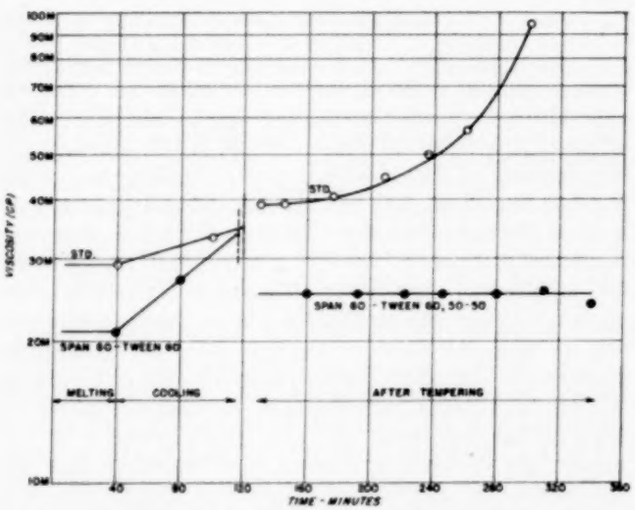

Figure 2. Effect of modifier on viscosity of coating during holding after tempering.

were held at 120° F. (49° C.) prior to cooling, the coating containing the Span-Tween mixture had the lower initial viscosity. The samples were cooled to about 78.8° F. (26° C.) and the temperature was raised slightly and held at 87° F. (30.5° C.). After tempering, viscosities were determined at intervals up to about 3 hours. The viscosity of the samples containing no additive increased with time while the samples containing an additive maintained a relatively steady viscosity. It is our belief that this characteristic would offer a definite advantage to the candy maker.

COMMERCIAL AND PILOT PLANT RUNS

We have shown that the addition of these modifiers influences the tempering time at a given temperature and alters the viscosity of the chocolate in most instances. As a result, a plant foreman who tempers by appearance may well temper his first trials of a modified chocolate improperly or inadequately. This is, in part, counter balanced by the greater leeway provided by the viscosity and stabilization at holding and enrobing temperatures that is conveyed by the use of the proper modifiers. Though these factors were recognized, they contributed to difficulties in early small plant-scale runs. A recent commercial run made in a medium sized plant was closely supervised and was witnessed by several interested persons from the industry. In this test, vanilla cream and coconut square centers were coated with a dark, sweet chocolate both with and without the addition of a blend of Span 60 and Tween 60, 60 to 40, at a total proportion of 1%. The data observed during the run are presented in Figure 3. Enrobing was carried out forenoon and during part of an afternoon with a typical noon hour shutdown. Some difficulties were encountered due to the fact that both chocolates were new to the enrober operator. Temperature control in the enrober was fair and it will be seen that the control for the sample containing the added modifier was poorer than for the standard chocolate. Accelerated aging tests have been carried out on these products and pictures of the pieces are shown in Figure 4. It is most interesting

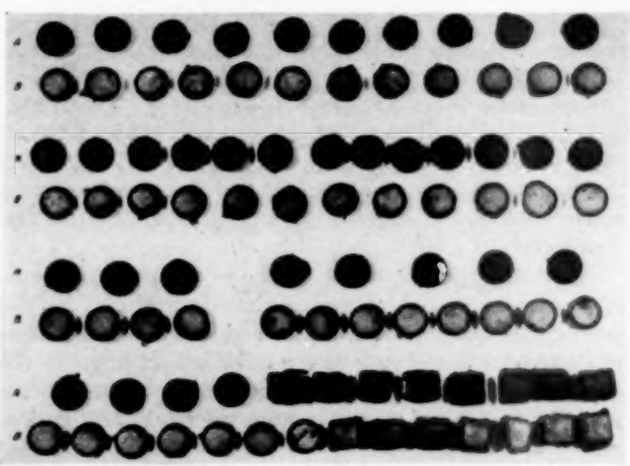

Figure 4. Results of accelerated tests on plant test samples. These samples were subjected to 12-hour cycling at 90° and 60° F. for 6 days. A: Chocolate coating plus 1% G-2034; B: Unmodified coating.

that even though the control of enrober temperatures for the samples containing the modifiers was poorer, they show a uniformly good resistance to fat bloom under the accelerated test conditions. The general opinion of the chocolate men present was that the standard was very well tempered.

EXTENT OF PROTECTION PROVIDED

The extent of protection provided under commercial practice is a most difficult question to answer. The effect obtained is one of retarding bloom formation and not prevention. The commercial tests described above are being evaluated in accelerated tests and in distribution tests, whereby boxes of the candy will be held under typical distribution conditions and examined periodi-

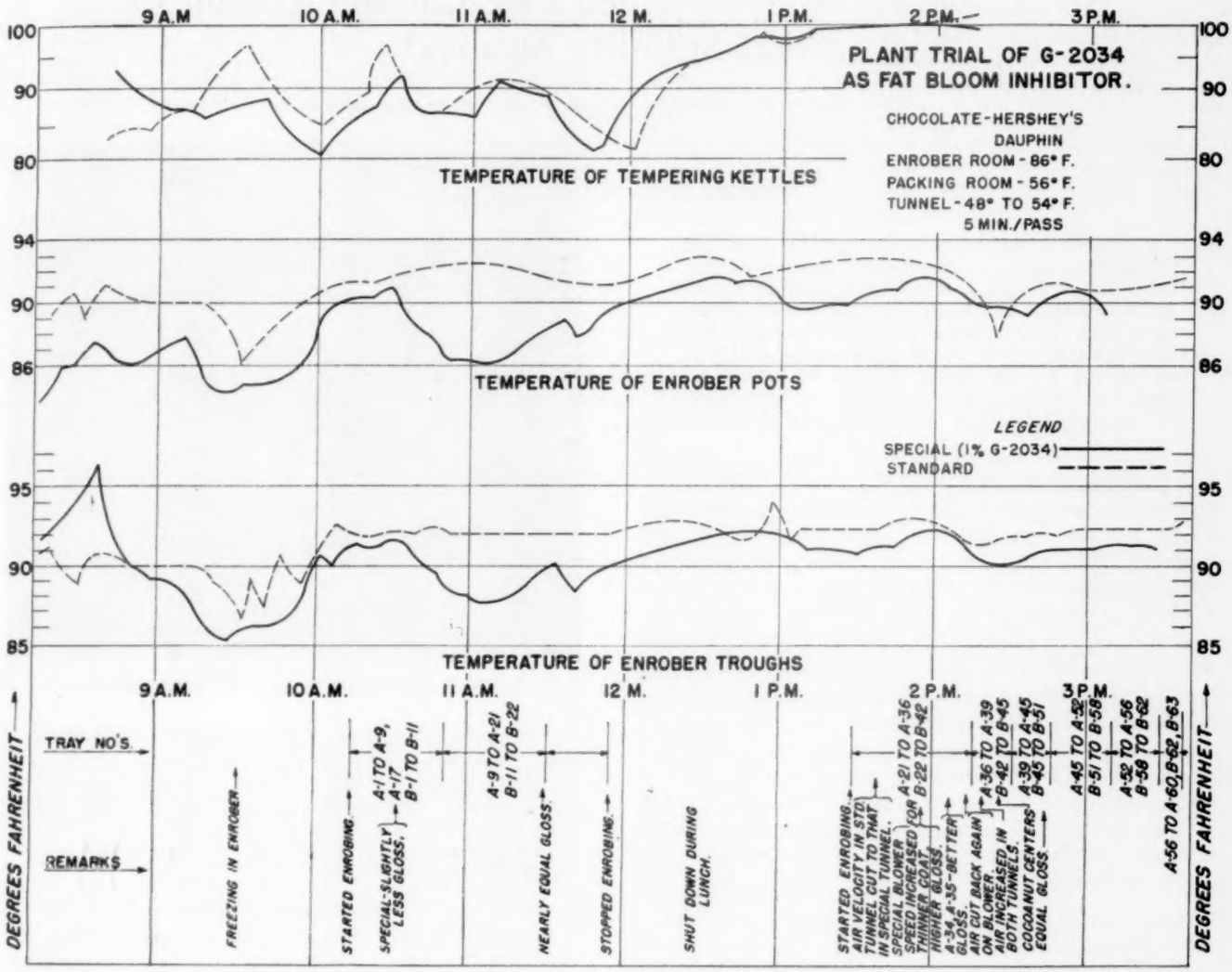
9 A.M
10 A.M.
11 A.M.
12 M.
1 P.M.
2 P.M.
3 P.M.
PLANT TRIAL OF G-2034
AS FAT BLOOM INHIBITOR.
CHOCOLATE-HERSHEY'S DAUPHIN
ENROBER ROOM - 86° F.
PACKING ROOM - 56° F.
TUNNEL - 48° TO 54° F.
5 MIN./PASS
TEMPERATURE OF TEMPERING KETTLES
TEMPERATURE OF ENROBER POTS
LEGEND
SPECIAL (1% G-2034)
STANDARD
TEMPERATURE OF ENROBER TROUGHS
DEGREES FAHRENHEIT
TRAY NO'S
REMARKS
FREEZING IN ENROBER
STARTED ENROBING
SPECIAL-SLIGHTLY LESS GLOSS.
A-1 TO A-9, A-17 B-1 TO B-11
A-9 TO A-21 B-11 TO B-22
NEARLY EQUAL GLOSS
STOPPED ENROBING
SHUT DOWN DURING LUNCH.
STARTED ENROBING AIR VELOCITY IN STD. TUNNEL CUT TO THAT IN SPECIAL TUNNEL.
SPECIAL BLOWER SPEED INCREASED FOR THINNER COAT HIGHER GLOSS
A-21 TO A-36 B-22 TO B-42
A-34, A-35 BETTER GLOSS
AIR CUT BACK AGAIN ON BLOWER
A-36 TO A-39 B-42 TO B-45
AIR INCREASED IN BOTH TUNNELS
A-39 TO A-45 B-45 TO B-51
COCOA NUT CENTERS EQUAL GLOSS
A-45 TO A-52 B-51 TO B-58
A-52 TO A-56 B-58 TO B-62
A-56 TO A-60, B-62, B-63

Figure 3. Conditions and observations during the plant-scale preparation of chocolate coated candies using modified and unmodified coatings.

cally. From these tests it is hoped that a correlation of the accelerated aging tests with commercial behavior can be established.

CONCLUSIONS

The extent of protection provided under commercial treatment has been improved by the addition of modifiers to the chocolate. Among the best of the modifiers are sorbitan monostearate and a blend of this material with poly-oxyethylene sorbitan monostearate (Span 60 and Tween 60). They are operable to a marked degree at a level of 1% on the chocolate.

Use of these modifiers entails no appreciable change in coating techniques. Since the modifiers alter the viscosity of the chocolate slightly, the enrober operator should be certain of attaining temper as determined by the method described in a previous paper *(1)* or by test pieces prior to starting the operation. A commercial run made with an operator who was not acquainted with the modified chocolate indicated that this procedure is workable.

The extent of protection provided, as defined in commercial terms, is not yet fully known though under investigation. With these tests we hope to be able to correlate the laboratory accelerated tests. However, from the results to date it appears that sufficient protection is gained to make the use of the modifiers most favorable from the standpoint of producing a higher quality of chocolate.

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An Automatically-Controlled Five-Cabinet System for Food Stability Studies[a]

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(Manuscript received August 11, 1951)

Five food storage cabinets are operated from one refrigerating unit and one dehydrating unit with provision for the independent variation, accurate control, and recording of the temperature and relative humidity in each cabinet. While the temperature and relative humidity can be varied between the limits of 40° to 100° F. (4.5° to 38° C.) and 10 to 95% respectively, the design favors operation of all cabinets at one temperature and different relative humidities.

In studies of the influence of moisture content and temperature on the stability of cereal products and other foods, storage tests must be carried out for several months. To obtain the desired information within a reasonable time and to avoid differences due to variations in properties of the food materials being stored, it is necessary to conduct simultaneous tests at different levels of one or the other of these variables. This paper deals with the design and operation of an automatically-controlled five-cabinet system which operates from one refrigerating unit and one dehydrating unit with provision for the independent variation, accurate control, and recording of the temperature and relative humidity in each cabinet.[b] The system was designed to operate at temperatures from 40° to 110° F. (4.5° to 43.5° C.) and at relative humidities from 10 to 100%.

GENERAL DESCRIPTION

A general view of the apparatus is shown in Figure 1. It comprises the food cabinets, temperature control system, humidity control system, and recording devices. The five cabinets are placed end-to-end and have an over-all length of 18 feet and a width of 6.5 feet. The cabinets are placed 4 inches from the floor in order that the temperature and humidity control devices and recorders may be located at convenient heights. The white square boxes between the recorders are the "control-boxes" which provide for the independent control of the temperature and humidity of each cabinet.

Food Cabinets

The useful part of each cabinet is 24 inches long, 22.7 inches deep, and 15 inches high, with a volume of 4.73 cubic feet. Some of the total volume of 6 cubic feet is needed for the entrance and exit of the conditioned air which is passed horizontally over trays. The unit including five removable trays is made of stainless steel (Figure 2). The food unit is placed inside another cabinet with a 5 inch space on all sides; the air in the annular space is circulated and the temperature controlled. The outer cabinet is constructed of black iron and has 4 inches of glass wool insulation on the outside.

Figure 1. Left front view of storage system.

The Control System

In order to simplify the controls and to obtain maximum precision, the temperature and humidity controls are two separate and distinct systems. The air in the annular space between the outer and inner cabinets has only its temperature controlled. The air passing through the inner cabinets and over the food has its humidity controlled. The temperature and humidity sensing elements are housed in the control boxes which are placed in the latter air stream.

Figure 2. Front view of food storage cabinet with removable stainless steel trays over which conditioned air is passed. This cabinet is located inside a larger one and the temperature of the air circulated in the annular space (5 inches on all sides) is controlled.

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[a] The work reported in this paper was undertaken in cooperation with the Quartermaster Food and Container Institute for the Armed Forces, and has been assigned number 349 in the series of papers approved for publication. The views or conclusions contained in this report are those of the authors. They are not to be construed as necessarily reflecting the views or indorsement of the Department of the Army.

This paper is based on a thesis presented to the Graduate School of the University of Minnesota by S. M. Barer in partial fulfillment of the requirements for the M.S. degree, August, 1950. Paper No. 2682, Scientific Journal Series, Minnesota Agricultural Experiment Station.

Presented at the Eleventh Annual Meeting of the IFT, New York, N. Y., June 20, 1951.

[b] Many details of the construction of the system have been omitted. These are available in the thesis of S. M. Barer on file in the Library of the University of Minnesota.

Figure 3 shows an inside view of the control box in which the sensing elements are placed.

Economic considerations caused the selection of a single cooling unit for the temperature stream and a single dehydrating unit for the humidity stream. Each of these units is connected by a

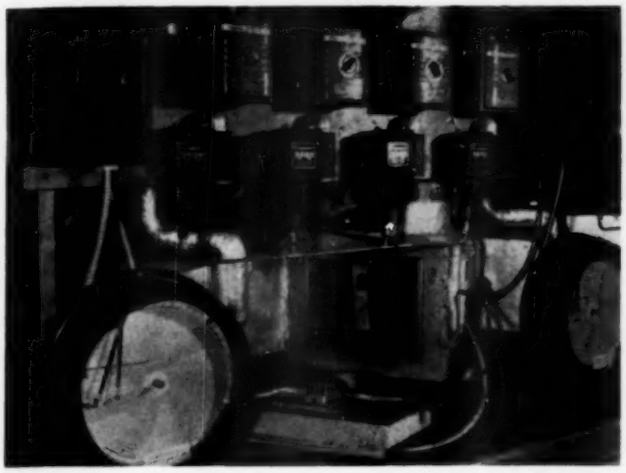

Figure 3. Control equipment above each cabinet showing an inside view of the control box.

manifold to the proper cabinet where the necessary quantity of cooled or dehydrated air can be taken from the manifold (Figures 4 and 5).

The temperature control system. Each cabinet is connected to the cold air supply manifold and to the return manifold. Between the supply and the return there is a bypass (Figure 4). A blower and heater are in the supply line to each cabinet. Specially constructed control valves are placed in the supply, return, and bypass lines. The three valves are connected together by a linkage so that they all operate as a unit, the bypass valve acting in the opposite direction from the other two. That is, when the supply and return valves are closing, the bypass will be opening.

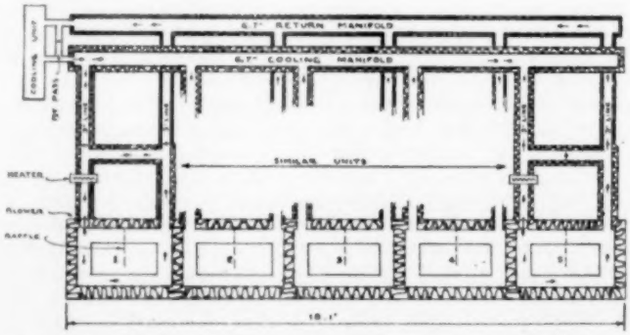

Figure 4. Schematic diagram of temperature control system.

If the cabinet is to be operated below room temperature, the controller positions the valves so that air is withdrawn from the manifold. When the temperature drops below that of the control unit the valves in the supply and return lines close somewhat with the bypass opening, thereby causing some of the air to be recirculated.

When operation is to be above room temperature, the supply and return lines are closed and the controller operates the electric heaters so as to produce the proper temperature. With this system each cabinet may be operated independently at different temperatures.

The temperature controllers are standard pneumatic controllers manufactured by the Minneapolis-Honeywell Regulator Company.

The humidity control system. The humidity control system is essentially the same as the temperature control system (Figure 5). A single dehydration unit is used, with each cabinet having a blower, cooling coil, steam humidifier, and three control valves. The operation of the control valves is similar to that of the temperature control valves. That is, if the humidity is to be low, the controller opens the supply and return valves so that dry air can be taken from the manifold. For high humidities the supply and return valves are closed and the steam humidifier is turned on. In order to remove the heat added by the steam, a small cooling coil is placed in the line. The humidity of each cabinet may be independently controlled.

The humidity controls are of the hair type manufactured by the Minneapolis-Honeywell Regulator Company. The air driers are of the activated alumina type supplied by the Pittsburgh Lectrodryer Corporation. At the present time, four driers are used, two being operated in parallel at any one time, while the other two are being regenerated (Figure 6). The capacity of these driers is about one pound of water each. To force the air through the driers, a 2 h.p. positive displacement Roots-Connersville blower is used. The capacity of the blower is greater than

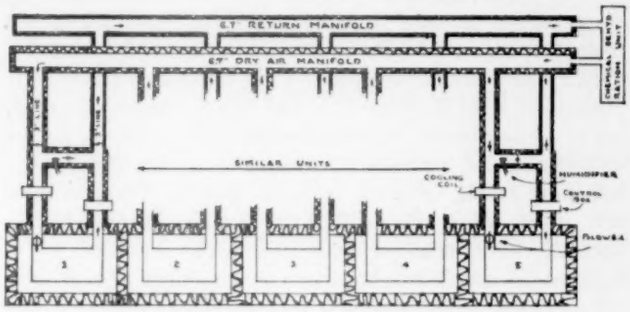

Figure 5. Schematic diagram of humidity control system.

can be handled by the driers, so that it was necessary to place a bypass around the driers. The air flowing through the drier is then controlled manually by a valve in the bypass line. The total flow through the inner cabinet is controlled manually by a valve in a second bypass around the blower.

Recorders. Since the controls are neither of the indicating nor the recording type, separate recorders are provided for each cabinet which record both the dry bulb temperature and the dew point. These instruments are Foxboro's dewcel type dew-point recorders.

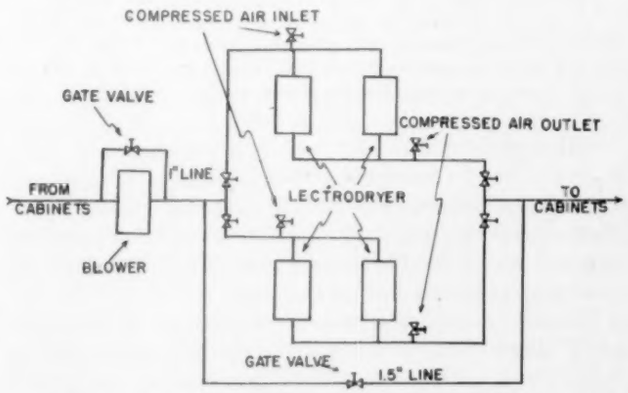

Figure 6. Schematic diagram of air dehumidifying system. Two driers are used in the system while a second pair is being regenerated. Bypass lines are provided around the blower and the driers; manually-operated valves control the air flow through the food cabinets and through the drier.

COST

The total cost of the five-cabinet system was approximately $13,300.00; this figure includes about $1,100.00 for modifications which were made to improve the performance based on tests of the empty cabinets set to

maintain the following four conditions: high temperature, high humidity; high temperature, low humidity; low temperature, high humidity; and low temperature, low humidity.

PERFORMANCE TESTS

In these tests, a change in the temperature setting for one cabinet was without influence on the temperature of the others: operating at high humidities at any temperature and at low humidities at low temperatures caused moisture to condense in the control box. Repositioning the steam humidifier largely eliminated this difficulty. The humidistats must be frequently recalibrated when used to maintain different humidity levels.

After these early improvements test runs of the empty cabinets lasting several days showed that the temperature of the air in the cabinets can be controlled over the range of 40° to 100° F. (4.5° to 38° C.) with a variation of about ± 0.5° F. The humidity control was satisfactory at low humidities. With the temperature adjusted to 100° F. (38° C.) and the humidity controls set at the minimum, the relative humidity in the different cabinets varied between 3.5 and 18% but remained quite constant within ± 1.0% in each cabinet. These results are good since the different humidistats were not specially calibrated for such low relative humidities, a calibration which is unnecessary since only one cabinet would normally be operated at such a low relative humidity in any storage trial. Further tests are being made to determine the efficiency of control at higher relative humidities.

DISCUSSION

The dehumidifying system has a rather low capacity since each pair of Lectrodryers can absorb only 2 lbs. of water and 3 to 5 hours are required to regenerate the alumina. While the system is adequate to maintain the moisture content of foods at the desired level during storage studies, a greater capacity would be useful when the cabinets are to be used as driers to bring the moisture content of the food materials to be studied to the desired storage conditions.

The drying capacity can readily be increased by the combined use of a refrigerated coil so constructed as to condense moisture at 35° F. (2° C.) and larger lectrodryers. The use of a nine row cooling coil with a 0.5 h.p. compressor would remove about 40 pounds of water per day and lectrodryers can be obtained which have a capacity of 6 or 18 pounds water each.

The present controls are quite satisfactory; however, operation could be improved if all of the controls were of the throttling type and possibly with automatic reset. The cost of such controls makes their use almost prohibitive.

Frozen Atlantic Oyster Investigations[a]

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(Manuscript received June 16, 1951)

Some factors in the preparation of a quality pack of frozen oysters are discussed. Use of strictly fresh oysters for freezing and a suitable type of container are very important. Proper washing methods are of value in lowering the quantity of "free liquor" which forms upon thawing the product. Freezing should occur at a reasonably rapid rate and storage at 0° F. or lower is necessary to minimize quality changes.

Although shellfish are highly perishable and their supply is, to a considerable degree, seasonal, relatively small quantities are preserved by freezing. This is particularly so with shucked oysters. The latest available figures (for 1950) indicate about 500,000 pounds of oysters were frozen during the year.

Numerous inquiries have been received by the Fish and Wildlife Service in regard to methods of packaging oysters and other factors having a bearing on quality over extended periods of frozen storage. A series of studies with packaged frozen products, including oysters, were undertaken in order to get answers to these questions *(4)*.

PROCEDURE

Freshly shucked Eastern oysters *(Ostrea virginica)*, prepared in the usual commercial manner and obtained from a shucking house, were used in the tests. A sufficient number of packages of each type to be tested were prepared to allow periodic examinations over a year's storage period. All packages were frozen at approximately —30° F. (—34.4° C.) and held in storage at 0° F. (—17.8° C.).

All of the packages were weighed regularly in order to determine their effectiveness in controlling moisture-vapor loss. Packages and packaging materials were examined for indications of brittleness, tears and other faults. One of each type of package was removed from storage at monthly intervals to ascertain the appearance of the frozen oysters with particular reference to desiccation or "freezer burn" and changes in quality which might have occurred during storage. After defrosting, the quantity and pH of the free liquor were determined, and palatability tests were made by a panel of impartial judges to determine the appearance, flavor, and texture of the oysters.

RESULTS

Weight loss. The average loss in weight for most types of packages tested amounted to only a few tenths of one percent, indicating a negligible loss in moisture-vapor.

With the bag-in-box type of container, weight losses averaged about the same whether or not an overwrap was used. This was true whether the bags were made of cellophane, specially coated paper, laminated cellophane and paper, rubber hydrochloride, or polyethylene. For types of rectangular containers which are generally used without an inner bag, a high quality overwrap was found to play an important part in preventing loss of moisture from the package.

[a] Presented at the Eleventh Annual Meeting of the IFT, New York, N. Y., June 19, 1951.

Negligible differences in weight losses were found in these tests between cartons containing single cellophane bags and those with duplex or double bags. Cylindrical containers were satisfactory for only relatively short periods of storage. After only a few months, extreme desiccation occurred on the top surface of the oysters in the head space which must be allowed for expansion during freezing.

pH and freshness. The change in pH of oyster liquor as freshness decreases has proven to be of considerable value in following changes in the degree of freshness of oysters *(1, 3)*. The liquor from freshly shucked Eastern oysters generally has a pH value of approximately 6.8. This initial value will vary somewhat, however, depending upon the locality from which the oysters were obtained, and other factors. This value decreases as freshness decreases, and oysters which have a pH value of about 5.8 are generally stale or very nearly so.

This measurement was made on the liquor from the oysters, after thawing, in all of the stored samples. In most instances, there was a decided drop in pH during the first month of storage, but after this, the pH values remained relatively constant at about 6.2 and at the end of the year's storage period were approximately the same as after only one month of storage. No marked deterioration of the oysters, as indicated by pH, was evident during the course of the storage period.

Palatability tests. On the basis of palatability scores, no outstanding differences were apparent in the quality of the oysters that were packaged in containers which provided good moisture-vapor retention. Slight darkening of the oysters occurred as storage time progressed, however, regardless of the type of container used. Some toughening occurred and the oyster flesh became more flabby as the storage period increased. Some alteration in flavor was also noticeable.

Free Liquor Content

After the oysters had been thawed in the package, the contents were weighed and allowed to drain on a coarse wire screen for two minutes. The free liquor was collected and weighed.

The amount of free liquor, calculated as percent of the entire contents of the package, was quite variable over the storage period and showed no consistent correlation with the time the oysters were held in storage. The values in a number of instances exceeded 20%, however, and 10 to 15% of free liquor was not at all uncommon. This quantity of liquor causes the oysters to be very "watery."

It was thought that the method used in handling the shucked oysters prior to freezing might influence the amount of free liquor which forms after thawing frozen oysters. Further tests were made with this in mind *(2)*.

It might be well, however, to first review briefly the method in common use for preparing shucked oysters commercially, in order that a better understanding may be had of its possible effect on free liquor content.

Oysters, after being shucked, must be freed of shell fragments and sand before being packed for distribution. They are first spread out on a "skimmer" or perforated surface to drain, followed by a preliminary washing on the skimmer with a stream or spray of water. They are then transferred to a large tank of water and are "blown" or vigorously agitated by forcing air into the bottom of the tank. After this treatment, they are again drained on a "skimmer" and are then ready for packaging.

When oysters are removed from the shell and placed in fresh water, they absorb some water. The amount absorbed is dependent, in part, upon the length of time the oysters remain in the water. If, however, the water in which the oysters are placed contains about 0.75% salt, the quantity of water absorbed will be considerably reduced. After being packed for shipment, the oysters may "bleed" or exude some liquid, the amount depending upon the method of washing and other factors.

The tests mentioned were therefore planned to determine the effect of blowing the shucked oysters in fresh water and in weak salt water for varying periods on the quantity of free liquor that forms after freezing and thawing the oysters. In brief, lots of shucked oysters receiving the following treatments were prepared: blown in fresh water for 3, 15, and 30 minutes; blown in 0.75% salt water for 3, 15, and 30 minutes; sprayed only with fresh water and not blown; and those prepared under commercial conditions at a shucking house. All lots were from the same plant and shellstock, and were otherwise handled in the same manner for packaging, freezing, and frozen storage. At monthly intervals, packages from each lot were removed from storage and the contents thawed. Palatability tests were made, the quantity of free liquor measured, and the pH value of the liquor was determined.

Marked differences were observed in the quantity of free liquor released by several of the lots of oysters upon thawing. The oysters that were blown for 15 and 30 minutes in fresh water released considerably more liquor upon thawing than did those blown for only 3 minutes. In contrast, the lots that were blown in the weak salt solution, whether for 3, 15, or 30 minutes, showed no appreciable differences in the quantity of free liquor which formed upon thawing the oysters but in each instance was less than that obtained for oysters blown for only three minutes in fresh water. The oysters that were sprayed only and not blown at all, yielded a value for free liquor upon thawing which was about the same as that for the three lots blown in the weak salt water. Finally, the commercially prepared oysters released the greatest quantity of liquid of any of the lots.

There was no indication that free liquor increased or decreased in volume in any of the lots during the storage period. The oysters in all lots were of about equal quality at the end of one year of storage, as based on palatability scores and pH values.

Freshness Is Important

The importance of freezing only strictly fresh foods is constantly being stressed. Freezing and storage cannot improve the quality of foods. On the contrary, unavoidable deterioration occurs. In general, if the quality of the product is poor at the time of freezing, it will be poorer when the product is thawed out. It will get no fresher during freezing and storage.

That the degree of freshness of shucked oysters at the time of freezing is of major importance in relation to their storage life, was shown during the course of these studies. Fresh oysters, taken from the same lot used for the other storage tests, were packed in friction top tin cans and held in crushed ice. When the quality of the oysters was considered to be approaching the lower limit of freshness, though still edible and salable, they were packaged in the bag-in-box type of containers, frozen, and placed in frozen storage with the other packages at 0° F. (—17.8° C.).

At the end of only one month of storage, this lot of oysters had a stale odor when thawed and was judged by the taste panel to be inedible. In contrast, the oysters that were strictly fresh at the time of freezing received a high score; in fact, they were judged as still being acceptable at the end of 12 months of storage. Although these findings are based on only one test, they indicate that the degree of freshness of the oysters at the time of freezing can have a marked effect on the ultimate quality and storage life of the frozen product.

Tests with Ascorbic Acid

As mentioned previously, some darkening of the oysters occurred during frozen storage. The cause of this is not definitely known. Proceeding on the hypothesis that it might be due to an oxidative change and that ascorbic acid has been used with varying degrees of success in retarding such changes in other frozen food products, a test series of oysters frozen after pretreatment with ascorbic acid was set up. They were packaged in moisture-vapor-proof materials and held in storage at 0° F. Concentrations of ascorbic acid up to 300 mg. per pound of oysters were employed.

During, and at the end of, approximately one year of storage, no appreciable differences in quality of the oysters were apparent. The untreated lot, used as a control, received substantially the same score as the lots containing ascorbic acid. No differences in the degree of darkening of the oysters were apparent.

Choice of Package

The necessity for providing adequate packaging protection for frozen fishery products is not as well appreciated as it should be. An apparent lack of understanding is still being shown by some packers in their failure to use satisfactory packages. Only too often do we find a makeshift container being used which is entirely inadequate for the job it is expected to perform.

The properly designed package must perform a number of functions. First of all, it must provide structural support during filling and freezing. It should of course be watertight so as to prevent leakage of the contents and discoloration of the package resulting therefrom before freezing and during thawing. It must provide protection against moisture-vapor loss during long periods in the dry air of a frozen storage room. In addition, the package must be convenient to fill and handle, and must prevent physical damage to the contents during distribution. Finally, it should have merchandising appeal, which is very important to consumer acceptance. In short, the package must "see the product through" from the time it is filled until the consumer is ready to prepare the product for the table. There is no need in this discussion to go into all the details regarding the designing of such a package. This can be adequately handled by conferring with any of the reputable package manufacturers.

A few suggestions might be made, however, to the prospective purchaser of packages for frozen oysters. The requirements for a package for frozen oysters are even more stringent than for most other frozen products because of the free liquor present and the amount of handling by hand prior to freezing, particularly in the smaller plants. The choice of the container is determined, in part, by the requirements of the individual producer, and whether packaging is done by hand or machinery. Since shucked oysters are a comparatively "wet" product, that is, they contain liquid in varying amounts, their "free-flowing" qualities, as well as the amount of handling which will be necessary during packaging and freezing, must be considered in the selection of a package. If the packaging is largely a manual operation, a water-tight container, such as a sealed moisture-vapor-proof bag within a waxed carton is desirable. Such a package may be turned at any angle before freezing without danger of having the contents spill. An overwrap may be used, if desired.

Cartons which are used without sealed bags should be overwrapped. When these cartons are used for a "wet" product such as oysters, some difficulty would undoubtedly be encountered in applying an overwrap by hand without spilling the contents. Such cartons therefore lend themselves better to automatic machine wrapping. They are also adapted to more specialized freezing equipment.

An overwrap for either type of package will provide added protection against leakage and normal wear and tear during distribution. It also provides an excellent medium for the attractive labeling and color combinations so widely used today on frozen food packages.

SUMMARY

In summary, the following points are to be stressed in the freezing of oysters:

1. Use only strictly fresh oysters. Stale oysters deteriorate very rapidly in quality in frozen storage.
2. Better flavor and a minimum of "free liquor" upon thawing will be obtained if the oysters, in preparation for packing, are given a minimum of washing in fresh water or are washed in 0.75% salt solution. The oysters should be drained thoroughly before being packaged.
3. Use an attractively designed, moisture-vapor-proof package, preferably of the rectangular type. Be sure it will seal readily and stay sealed.
4. Leave only sufficient head space, when filling and closing the package, to allow for expansion of the oysters during freezing. Too large an air space in the top will allow localized "freezer-burn" and unsightly discoloration of the oysters.
5. Freeze immediately at a low temperature.
6. Store at 0° F. or below if a reasonable storage life is to be expected.
7. Strict attention should be given to sanitation and cleanliness in all phases of the plant operation.

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Influence of Storage Conditions on Frozen and Canned Apple Juice Concentrates[a]

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Apple juice concentrates prepared by three different methods have been stored at 0° and 75° F. (—18° and 24° C.) and the changes in flavor, color, and iron concentration have been followed. Storage at 0° F. for one year produced no important flavor changes. Storage at 75° F. for more than three months caused development of an objectionable amount of off-flavor.

The rise in popularity of frozen orange juice concentrate prompted quick development of concentrates of several other fruit juices. Most of these have been prepared as four-fold concentrates, to be diluted with three volumes of water. Among these is apple juice concentrate. This paper describes storage studies on four-fold apple juice concentrates prepared from Western apples according to three methods given in previous publications from this Laboratory *(5, 11)*. Two of these methods involved the return of volatile essences. Essence and essence-free (stripped) juice were concentrated separately before they were combined to make the finished four-fold concentrate. This procedure was based on the suggestion of several previous workers, as reviewed in our preceding publication *(11)*. One of the important investigations was that of Milleville and Eskew, who described a commercially successful method for recovery of natural apple flavors from apple juice *(7, 8, 9)*. They also suggested preparation of a full-flavored concentrate by addition of volatile apple flavor concentrate to commercial apple juice concentrate. Eskew, Phillips, Homiller, Redfield, and Davis have recently presented a discussion of the engineering aspects of preparation of a frozen four-fold apple juice concentrate *(3)*.

Concentrates could conceivably have a different storage life from single-strength juices, since the concentration of the reactants is much higher. Deterioration of single-strength juices has been the subject of many investigations, of which perhaps the latest summaries are those of Smock and Neubert *(10)* and Lee, Robinson, Hening, and Pederson *(6)* on raw and pasteurized juices and concentrates in low-temperature storage.

The work to be described here was concerned with frozen apple juice concentrate and with a flash-pasteurized, hot-filled concentrate for room-temperature storage.

EXPERIMENTAL PROCEDURE

Processing and packing of apple juice concentrate. The apple juice concentrates were prepared as described earlier, separately concentrating the essence at atmospheric pressure and the stripped juice under vacuum *(11)*. A description of the steam-injection heater mentioned in this connection has been already published *(2)*. The juice was pressed from a mixture of 70% Winesap and 30% common Delicious apples. These apples were "firm ripe" in maturity. The juice was clarified by use of a commercial enzyme preparation, filtered, and the clarified products from a group of pressings were combined, frozen in 30-pound cans, and stored at 10° F. (—23.5° C.) to provide a uniform stock of juice.

Concentrates were prepared in three different ways, as follows:

Method A. The juice was concentrated to six-fold and the concentrate was cut back to four-fold with single-strength juice.

Method B. The juice was stripped of volatile flavoring constituents by flash evaporation, and the residue was concentrated to slightly over four-fold. The proper amount of volatile flavoring constituents (concentrated in a fractionating column to 1% of the original juice volume) was added to give a full-flavored concentrate.

Method C. The juice was stripped of volatile flavoring constituents, the residue was concentrated to six-fold, the proper amount of volatile flavor concentrate was added, and the mixture was cut back to four-fold with fresh juice.

For this set of experiments, the concentration of the stripped juice was carried out at 125° F. (51.5° C.). Each lot of full-flavored concentrates was divided into two equal portions. One portion was filled, at room temperature, into 211 x 212 sanitary fruit enamel cans, frozen, and held at 0° F. (—18° C.). The other portion was heated to 200° F. (93.5° C.) in a high-velocity pasteurizing tube, hot-filled into similar cans, sealed, inverted for three minutes, cooled in running cold water, and stored at 75° F. (24° C.). Samples of single-strength juice of the same lot used in preparing these concentrates were packed in similar manner, in 307 x 409 fruit enamel cans.

A second pack was made, in glass, and in cans with a special two-coat enamel, with further protection furnished by a side-seam stripe of the enamel applied after the can was formed. The can size used was 202 x 314, and for the glass pack, "baby food" jars were used with a composition-gasketed lid, closed with a commercial capping machine drawing a 15 inch vacuum (7.4 p.s.i.a.) before seating. The concentrate was prepared by Method B only, from juice prepared and stored as described above. The filling procedures described above were used to make a pack for freezing and one for 75° F. (24° C.) storage in the cans. Only a pack for the room-temperature storage was put in the glass jars.

In the tables of data, the fruit-enamel-packed series is referred to as "Frozen" or "Canned" with the method of concentration included. The samples packed in the two-coat enamel or glass are specifically referred to in terms of the container type.

For the series in which methods of preparation of the concentrate and the frozen and canned products are to be compared, the single-strength juice had an acidity of 0.44% (as malic acid), a pH of 3.72, and a soluble solids concentration of 14.0% (as sucrose, from the refractive index at 20° C.). The concentrate had a pH of 3.65 and a soluble solids concentration of 48.3%. For the series comparing the containers, the juice acidity was 0.38%, the pH was 3.77, and the soluble solids concentration was 13.3%, and the concentrate had a soluble solids concentration of 47.5%.

Appraisal and analytical procedures. The appraisal of the samples was done in two ways, by scoring procedures and by the triangular taste test. For comparing several samples, scoring methods were used, with a taste panel of about 15 persons.

[a] Presented at the Eleventh Annual Meeting of the IFT, New York, N. Y., June 20, 1951.

[b] Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, U. S. Department of Agriculture. Report of a study made under the Research and Marketing Act of 1946.

In the series packed in fruit enamel, the four types of frozen samples were served together four times, as also were the four types of canned samples. This was to provide a comparison of the effect of storage on the relative quality of the three concentrates and the single-strength juice. In addition, comparisons were made of the frozen and the canned packs for each method, each pair being served together twice. In the second series, packed in the two-coat enamel and in glass, all samples were served together four times. At the first and second storage periods, three samples were tasted. At the fourth storage period (29 weeks) an additional sample, held at —30° F. (—34.5° C.) for 29 weeks, was inserted as a reference.

Triangular taste tests *(4)* were used where it was desirable to check by an additional method whether two samples were or were not to be considered different.

For tasting, the concentrate samples were diluted with 3 volumes of distilled water, giving a reconstituted juice of the same Brix reading as the single-strength juice. All samples were served at about 70° F. (21° C.) with no more than 1° difference between any two samples.

All tasting was done in a room under illumination with a large sodium vapor lamp, since this served to avoid perception of color differences between samples.

Iron analyses were made by an orthophenanthroline method *(1)*, and are reported on the basis of the samples as stored.

Color determinations were made on the reconstituted juices, at the end of several of the storage periods, with a Hardy-General Electric recording spectrophotometer for the spectrum from 400-700 mμ.

RESULTS AND DISCUSSION

Statistical analyses were carried out on most of the scoring results by the method of analysis of variance. The figures for least difference required for significance at probabilities of 0.01 and 0.05 are given immediately below each column of average scores. The discussion below is based in part on these results.

Comparison of methods of concentration. The concentrate prepared by Method A was judged inferior in natural flavor to the other concentrates and to the single-strength juice, as reported in the previous paper *(11)*, and this difference carried through in frozen storage as shown in Table 1. In frozen storage the samples held their relative positions closely, and careful judgment led to the conclusion that there had been little or no deterioration. For the storage samples at 75° F. (24° C.), the natural flavor scores were apparently influenced by the off-flavor which had developed. It did appear that the better flavor given by adding volatile flavor concentrates became much less pronounced after 27 weeks at 75° F. (24° C.), and after 52 weeks there appeared to be little or no benefit.

TABLE 1

Taste scores for reconstituted juices obtained by different methods of concentrate preparation

Type of juice or concentrate	Freedom from off-flavor [c]				Fullness of natural flavor [d]			
	Storage time, weeks				Storage time, weeks			
	1	12	27	52	1	12	27	52
Frozen								
Method A	8.4	8.7	9.0	8.5	5.9	6.2	6.7	6.6
Method B	8.1	9.0	9.0	8.6	7.8	8.4	8.1	7.5
Method C	8.5	9.2	9.0	8.7	7.9	8.5	8.4	7.8
Single-strength juice	7.7	8.5	7.7	7.6	7.6	8.2	7.9	7.4
Least difference for significance at								
0.01	0.9	1.3	0.9	1.0	1.1	1.3	1.1	0.7
0.05	0.7	0.9	0.6	0.7	0.8	0.9	0.7	0.5
Canned								
Method A	8.3	5.9	5.6	6.0	6.3	6.2	5.6	5.6
Method B	8.5	8.2	6.7	6.4	7.8	7.4	6.7	6.2
Method C	8.7	8.0	7.2	6.7	8.1	7.9	6.8	6.5
Single-strength juice	6.8	6.5	5.1	4.6	7.0	6.9	5.8	5.0
Least difference for significance at								
0.01	0.9	1.0	0.7	0.7	0.9	0.6	1.1	0.8
0.05	0.6	0.7	0.5	0.5	0.7	0.4	0.8	0.6

[c] Score of 10 described as "no off-flavor."
[d] Score of 10 described as "full natural flavor."

Comparison of frozen and canned products. When direct comparison was made between frozen and canned concentrates and juices, the better quality retention by low-temperature storage was shown strongly (Table 2). The first comparison of frozen and canned products was made after 6 weeks had elapsed, and the differences were then so evident that no statistical calculations were made. Since at 6 weeks the difference was evident, the question arose as to whether an important initial difference had been present. In a separate experiment, a batch of concentrate was prepared by Method C. One portion was filled without pasteurization and frozen, and the other lot was hot-filled as described in the experimental procedure. The two lots were compared by the triangular taste test. The results (Table 3, first two comparisons) showed that there was no significant difference in the first two days after packing, with a significant difference in tests on the fifth and sixth days after packing. Such a difference can hardly be of commercial importance. In another test of this sort, an initial triangular taste test (Table 3) was run to compare the cold-filled and hot-filled samples immediately after packing in the two-coat enamel cans (see Comparison of containers and their effects). This time all samples were put at —30° F. (—34.5° C.) immediately and held there over the period required to run the tests. The result corresponded to a significant difference, with preference only slightly in favor of the frozen. Careful comparison led us to the conclusion that the difference was detectable but probably not important to consumers.

TABLE 2

Direct comparison of frozen and canned concentrates. Taste scores on reconstituted juices

Type of juice or concentrate	Freedom from off-flavor [a]				Fullness of natural flavor [a]			
	Storage time, weeks				Storage time, weeks			
	6	13	27	55	6	13	27	55
Method A								
Frozen	8.0	8.5	8.2	8.7	5.8	5.9	7.7	6.5
Canned	6.5	5.6	4.8	5.2	5.9	6.5	5.6	4.8
Method B								
Frozen	9.0	9.4	9.3	8.9	7.8	8.2	8.4	8.0
Canned	7.7	5.7	5.2	5.4	6.9	6.1	5.7	5.4
Method C								
Frozen	9.0	9.6	9.1	8.6	7.8	8.2	8.5	8.2
Canned	7.4	5.2	5.3	5.1	7.1	6.4	5.7	5.2
Single-strength juice								
Frozen	9.2	9.2	9.1	8.1	8.5	8.6	8.6	8.0
Canned	5.9	4.4	3.7	3.9	6.5	5.6	4.8	4.1

[a] See footnotes to Table 1.

In optional comments, tasters described the canned samples, after 27 weeks of storage, as "musty," "oily," "stale," "pineapple," "cooked," generally indicating their dislike. At 12 weeks, most of the comments were about a "cooked "flavor, with no real dislike expressed. We felt that this taste panel had acquired a favoritism

TABLE 3

Results of triangular taste tests

Comparison	Storage conditions	No. of judges	No. of correct answers	No. stating "no diff."	No. correct answers necessary for significance at		Significance at P		Preference [f]	
					0.01	0.05	0.01	0.05	1	2
Frozen vs. canned, method C	1 and 2 days after preparation	40	13	4	22	20	No	No	5	6
Frozen vs. canned, method C	5 and 6 days after preparation	40	23	3	22	20	Yes	Yes	6	13
Frozen vs. canned, two-coat enamel	No storage	57	32	1	29	27	Yes	Yes	16	11
Two-coat enamel vs. glass	12 weeks at 75° F.	54	24	3	27	25	No	Yes	12	10
Two-coat enamel vs. glass [g]	29 weeks at 75° F.	29	22	1	17	15	Yes	Yes	3	12

[f] Those of judges who correctly identified duplicates. The figure 1 indicates the pack first mentioned in comparison and 2 indicates the pack mentioned last.
[g] Discontinued after 2 replications.

for the natural apple juice flavor, and was more critical than the usual consumer would be toward the off-flavor acquired during storage at 75° F. (24° C.). Our own best judgment and discussions of the samples with manufacturers and distributors of apple juice led to the conclusion that the samples stored for 12 weeks were probably acceptable, that those stored for 27 weeks were borderline in acceptability, and that the samples stored for 52 weeks were unacceptable and very poor.

The canned samples were not graded as low numerically where no frozen storage samples were present as they were in the presence of frozen samples (Table 2). This familiar behavior was the cause of the extra work of the direct frozen-canned comparison.

Comparison of containers and their effects. As described in the experimental procedure, samples of concentrate were packed for storage at 75° F. (24° C.) and 0° F. (—18° C.) in two-coat enamel cans and in "baby food" jars for storage at 75° F. According to the results in Table 4, the quality deteriorated at 75° F. regardless of the container type. The frozen samples held at 0° F. for 29 weeks were scored nearly identically to samples held at —30° F. (—34.5° C.) for the same period. The up-grading of the frozen sample after the initial judging appeared to be another example of the familiar tendency for a good sample to receive better scores, when graded with a poorer sample, than it would alone or with other samples of similar quality.

At 12 and 29 weeks, samples of the can pack and glass pack were compared by the triangular taste test. Differences at 12 weeks (Table 3) were detectable but apparently not important on a preference basis. A definite difference at 29 weeks appeared to be in favor of the glass pack. The cause of the difference was not known. The headspace in the cans was 0.40 to 0.45 inch and that in the jars 0.6 to 0.7 inch. Vacuum measurements were made at the time of the tasting period after 12 months of storage, using a puncture-type canners' test gauge. With this instrument, vacuum readings for the jars were 13 to 14 inches of Hg (7.8 to 8.3 p.s.i.a.), those for the two-coat enamel cans were 9 to 10 inches of Hg, and those for the fruit enamel cans were 5 to 7 inches of Hg (11.3 to 12.2 p.s.i.a.).

Further work is in progress to determine, for concentrates stored at 70-75° F., the effects of deaeration and other variations in amount of contact with air during processing and packing.

TABLE 4

Comparison of concentrates stored in different containers. Taste scores on reconstituted juices

Type of pack	Freedom from off-flavor [h]				Fullness of natural flavor [h]			
	Storage time, weeks				Storage time, weeks			
	0	6	12	29	0	6	12	29
Frozen, two-coat enamel	8.9	9.4	9.4	8.9	7.8	8.9	8.8	8.6
Glass, 75° F.	8.9	7.3	5.6	3.1				
Two-coat enamel, 75° F.	9.0	7.3	4.8	2.7	7.6 7.9	6.8 7.0	5.9 5.4	3.8 3.5
Frozen, two-coat enamel, 29 weeks at —30° F.	....	....	....	9.0	....	....	....	8.4
Least difference for significance at								
0.01	....	1.1	1.2	1.1	....	0.9	1.1	1.5
0.05	....	0.8	0.9	0.8	....	0.7	0.8	1.1

[h] See footnotes to Table 1.

Influence of iron accumulation. The concentrates and juice stored in fruit enamel cans accumulated considerable amounts of iron during storage (Table 5). The samples were analyzed and reported at the concentration at which they were stored; that is, the concentrates were not reconstituted for analysis. While this method of recording could give some confusion in interpreting results, we felt it was preferable to recording them on the reconstituted basis. The iron determinations were not made on the concentrates before the six months of storage sampling time, but the differences between iron concentrations in frozen and canned products are clearly evidence of corrosion. This cor-

TABLE 5

Results of iron analyses on stored samples

Storage time weeks	0	6	12	28	52
	p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*
Samples in fruit enamel					
Frozen					
Method A	....	....	....	17	18
Method B	....	....	....	22	27
Method C	....	....	....	22	26
Single-strength juice	....	....	6	5	5
Canned					
Method A	....	....	....	35	69
Method B	....	....	....	62	68
Method C	....	....	....	62	68
Single-strength juice	....	....	30	45	56
Samples in two-coat enamel					
Frozen	10	11	11	15	....
Canned	10	13	12	15	....
Samples in glass	10	11	11	15	....

rosion showed in many small spots, and was particularly marked along the side seam and in straight scratches in the enamel of the can lid. Similar scratches showed in the cans which had contained the frozen samples, but they were not visibly corroded.

These results led us to conclude that the concentrates are no more (and possibly less) corrosive than single-strength juices, taking into account the relative gains in iron concentration.

Concentrates in the two-coat enamel cans (with side-seam stripe) and in the glass jars showed little or no iron accumulation. The slight increase in iron concentration which appears to have occurred in all samples was not readily explainable.

The principal point of interest in considering these results was that the flavor changes in the concentrates appeared to bear no relationship to the relative increases in iron concentration. This was admittedly tested only by "best judgment" tasting, but by such methods it did not appear that the concentrates in fruit enamel were better or worse than those in the two-coat enamel, considering the condition after 6 months of storage at 75° F. (24° C.).

Color changes. The transmittance curves in Figures 1 and 2 represent the color changes which took place in the samples during storage. Figure 1 shows that the concentrates in cans with two-coat enamel changed during storage at 75° F. principally to give less transmittance in the yellow-green region. Only one curve is shown for the frozen samples, since those taken at each sampling time were superimposable on the curve for the unstored sample. At six months, the differences in color between the frozen and the canned samples were visible to the eye but not marked, and were judged to be unimportant.

The transmittance curves in Figure 2 were made at 6 months of storage, on the samples stored in fruit enamel cans. These curves are shown to illustrate the apparent difference in the type of color change between single strength juice and concentrates. The frozen single-strength juice showed a transmittance curve markedly different from that of the reconstituted frozen concentrates; the difference was readily apparent to the eye. The reconstituted concentrate was definitely lighter, and one can only conclude that the difference was due to the stripping and concentration steps. This view was expressed in the previous publication *(11)*. This difference was greatest at about 440 mμ, where the juice had transmittance of 6% and the reconstituted concentrate had transmittance of about 24%. After 6 months of storage, in the canned single-strength juice the color differences were greatest in the 400-500 mμ range. The concentrates again showed the same change as mentioned above, in the yellow-green region.

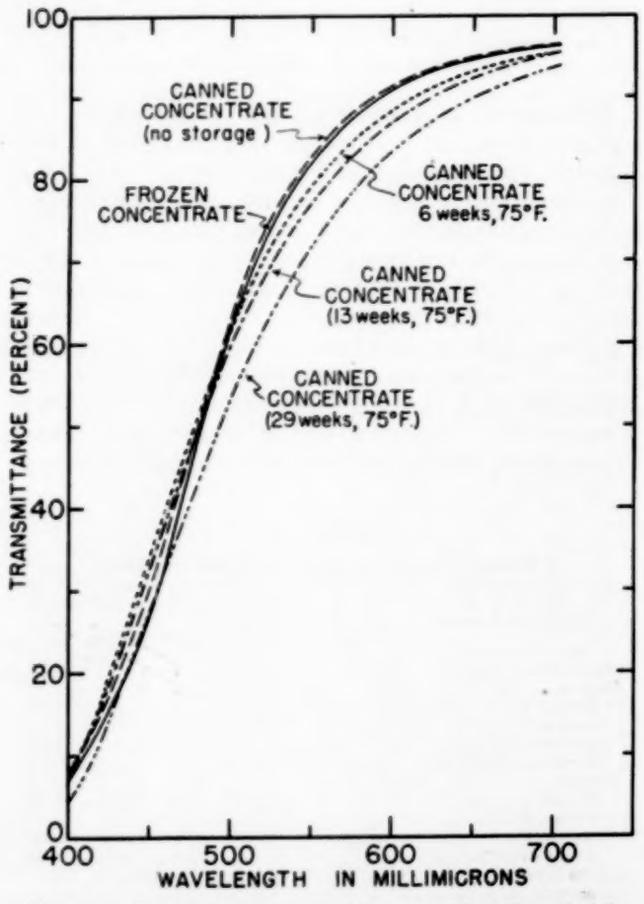

Figure 1. Transmittance curves for reconstituted apple juice concentrates at various storage times.

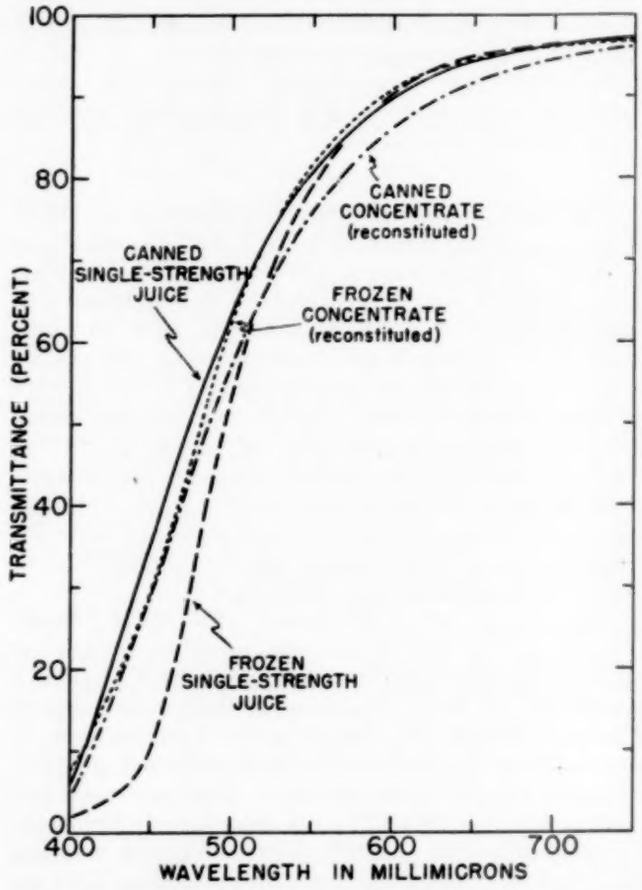

Figure 2. Transmittance curves for apple juice and reconstituted apple juice concentrate after 6 months of storage.

Clarity changes. There were no precipitates or changes in clarity in the concentrates described in this paper. This is not true of concentrates from juices of all

apple varieties. An experimental pack of Gravenstein concentrate, clarified and packed under similar conditions and stored at 75° F. (24° C.) for six months, showed a heavy turbidity with some precipitate.

CONCLUSIONS AND SUMMARY

Apple-juice concentrates, prepared by three procedures, were stored at 0° F. (—18° C.) and at 75° F. (24° C.) for one year, and compared with each other and with single-strength juice, stored similarly, at various times during the one-year period.

The return to the concentrate of volatile flavors separated during the preparation of the concentrate appeared to be desirable, and the advantage persisted as long as the samples were acceptable.

The frozen concentrates (and single-strength juice) maintained good quality for the entire year. The products stored at 75° F. acquired off-flavors, and were judged to be still acceptable after 12-13 weeks, of doubtful acceptability after 27-29 weeks, and very poor after 52 weeks.

There was no important difference between concentrates packed, without heating, for frozen storage and those hot-filled, by flash-heating, for storage at 75° F., when the samples were compared within one to six days after packing.

Concentrates and juice put in fruit enamel-coated cans showed accumulations of iron during storage at 75° F., with evident can corrosion. Concentrates put in cans with a two-coat enamel with extra side-seam stripe showed little or no iron accumulation at 75° F. It appeared, however, that concentrates packed in either of the enamels acquired off-flavor at about the same rate. After 29 weeks at 75° F., the juice from concentrate stored in glass jars was preferred to that stored in the two-coat enamel, but both were judged to be of doubtful acceptability.

Color differences between frozen and canned (75° F.) products were visible after 6 months or 12 months of storage, but it was felt that the differences would be unimportant to the consumer at either time. When stored at 75° F., there was apparently a qualitative difference in the color change between the single-strength juice and the concentrates. Frozen juices or concentrates did not change visibly during storage.

Acknowledgments

The authors acknowledge with thanks the work of Elizabeth McComb and Harold C. Lukens of the Physicochemical and Analytical Division of this Laboratory in performing the iron analyses and the color determinations.

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Flavor Fortification of California Frozen Orange Concentrate[a]

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(Manuscript received June 28, 1951)

The results of an investigation of the volatile materials evolved during the evaporation of California Valencia oranges are presented. Under the conditions of these experiments, the volatile aroma and flavor lost during evaporation could be restored by the addition of cold-pressed peel oil or of orange puree prepared by crushing or slicing the whole fruit.

The low-temperature, high-vacuum evaporation process used to produce concentrated orange juice removes not only water but also a large proportion of volatile constituents which give the product its characteristic fruity flavor and aroma. "Reconstituted juice" made from such concentrate is deficient in these characteristics when compared with the original juice, although it possesses little or no processed flavor. A method patented by MacDowell, Moore, and Atkinson *(9)* for restoring flavor and aroma to concentrates has been adopted by the industry for the preparation of better quality products. With this process, juice is concentrated at low temperature to about 55° Brix, and sufficient fresh single-strength juice (cut-back juice) is added to restore some of the volatile flavoring constituents lost during evaporation. The addition of the cut-back juice also lowers the concentration to 43° Brix.

This paper is a report of studies to determine what volatile fractions from the orange juice are responsible for the characteristic flavor and aroma, and whether or not any of these volatile fractions can be used to supplement or replace the cut-back juice for flavor fortification of the concentrate. This was done by fractionating the

[a] Report of a study made under the Research and Marketing Act of 1946.

[b] Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, U. S. Department of Agriculture.

juice without heat damage by the low-temperature evaporation process, and by recombining the fractions in various combinations.

LOW TEMPERATURE EVAPORATION METHODS EMPLOYED

The orange juice concentrates were produced in a pilot plant model single-stage, single-effect, falling-film evaporator composed essentially of a 3-inch stainless steel tube 13 feet long, jacketed with warm water and equipped with a liquid-vapor separator and cold surface condenser (Figure 1). This unit was

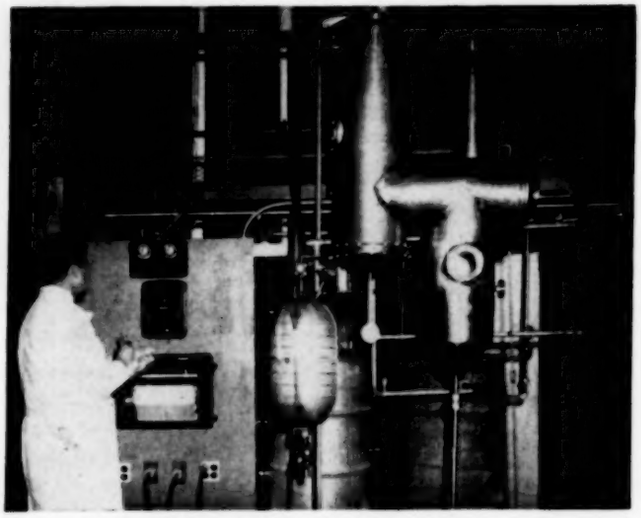

Figure 1. Pilot plant evaporator.

designed to provide, as nearly as possible, evaporation conditions similar to those used commercially. The heating medium was warm water at 95-97° F. (35-36° C.), the evaporating temperature was 58-62° F. (14.5-16.5° C.), and the operating pressure was 12-14 mm. of mercury. Evaporation was carried out batchwise, requiring approximately 30 minutes. In addition to the conventional cold surface condenser at 35-40° F. (2-4° C.), cold traps immersed in a dry ice-alcohol mixture at —108° F. (—78° C.) were placed in the vacuum line to condense the residual vapors.[e] Process grade fruit was used in all experiments and no special attempt was made to control the various processing steps to produce concentrates of exceptional quality. Under these operating conditions, orange juice was fractionated into three parts, namely, 1, a 55° Brix concentrate; 2, a water condensate possessing some orange aroma, collected from the cold-surface condenser; and 3, an oil-water emulsion possessing a strong orange aroma, collected from the dry ice traps (Figure 2).

Orange Flavor in Water Condensate

Lots of 55°-Brix concentrate were reconstituted to single strength with proportionate amounts of the water condensate obtained from the cold surface condenser. Such juices had a more fruity aroma than similar juices reconstituted with distilled water but were flat in flavor as compared to the original juice. In order to utilize the water condensate in the preparation of fortified concentrates for storage studies, it was concentrated by a continuous vacuum distillation. The condensate was metered to a packed distilling column shown in Figure 2, and the rectified volatiles were collected in a cold water-jacketed receiver which was connected to the vacuum line through a system of dry ice traps. Conditions of rectification were varied in different runs so that the temperature of the vapor at the top of the column in each case was either 71°, 100°, or 110° F. (22°, 38°, or 43° C.), with a temperature drop of 10° F. (6° C.) between the top and bottom of the column. The feed rate and take-off rate of the column were adjusted for each run so that no alcohol or odor was detectable in the still residues. The efficiency of the column was checked with a 0.003% ethyl alcohol solution, and the still residues were tested by the iodoform reaction to assure that alcohol recovery had been complete.

The concentrated volatile materials stripped from the condensate consisted of an aqueous mixture in the receiver containing traces of volatile oil and an oil-water emulsion in the dry-ice traps. These fractions were combined for all subsequent studies of concentrated condensate. Three degrees of concentration were obtained in different runs, the greatest being, 110-fold, attained by the reduction of water condensate to 1/110 of its original volume.

The concentrated material possessed an orange aroma and, on analysis, was found to contain approximately 0.1% volatile oil, 3% ethyl alcohol, and traces of methyl alcohol and ammonium compounds. When the volatile oils were removed from such mixtures by ether extraction, all of the orange aroma was lost. These observations indicated that the orange aroma present in the water condensates collected under the conditions of these experiments was probably due to dissolved volatile oil present in insufficient amounts to have a significant flavor effect.

This view is further supported by the work of Kirchner *(8)* who has analyzed the water condensate obtained during the concentration of large volumes of orange juice. The only constituents found after ether extraction were formaldehyde, methyl alcohol, acetaldehyde, ethyl alcohol, acetone, furfural, and an unidentified acetate ester, none of which appears to contribute orange flavor and aroma, although the extracted oils were rich in these qualities.

Various lots of 43°-Brix concentrate were prepared by adding proportionate amounts of concentrated condensate of 20-fold, 80-fold, or 110-fold concentration (volumetrically) to lots of concentrate of the appropriate solids content. They developed off-flavors on storage at 0° F. (—18° C.), the ones fortified with material concentrated at the lowest temperature being slowest to show changes in flavor. One of the common descriptions applied to juices reconstituted from such products after storage was "apricot-like". These experiments appear to be in accord with the statements of Heid *(5)* and Kaufman and Campbell *(6)* on the use of condensates for fortifying orange concentrates.

FORTIFICATION WITH TRAPPED OIL

When the 55°-Brix concentrate was fortified with the material from the dry ice traps in the evaporator vacuum line and reconstituted to single strength with distilled water, the characteristic orange flavor was restored.

Studies were then made to determine the amounts of trapped oil necessary to add to concentrates for flavor fortification. Varying amounts of trapped oil were added to portions of a uniform lot of concentrate which were reconstituted with distilled water and taste-tested. These studies showed a direct relationship between flavor quality of the juices and their recoverable oil contents. A definite improvement in flavor and aroma resulted when the oil content in the reconstituted juices was approximately 0.005% (v/v) or above, and an optimum flavor was obtained with about 0.01% oil. When the oil values were increased above approximately

[e] The efficiency of the dry ice trapping system was checked with liquid nitrogen traps as described by Walker and Patterson *(10)*.

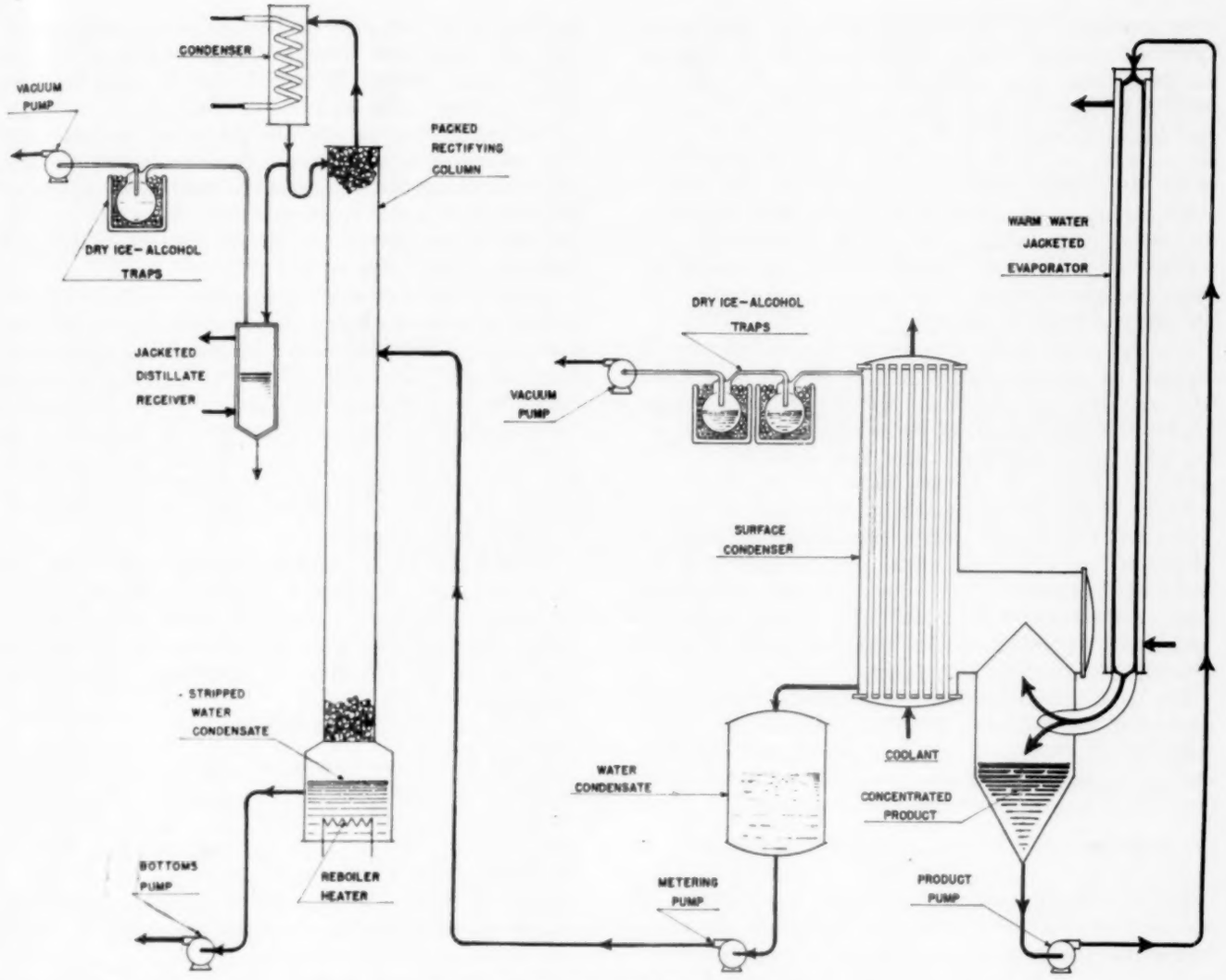

Figure 2. Flow diagram of procedure.

0.015%, the flavor was too intense for reliable judgment of differences. A majority of the taste panel described the juices with such terms as "oily", "burning taste", "artificial", or "bitter". In the lower-oil-content range of a trace to 0.005%, the taste panel was unable to detect differences of flavor and aroma. Such studies on the "trap fraction" have indicated that the characteristic orange flavor appears to be associated primarily with the trapped volatile oil fraction.

To further indicate the relationship between flavor and volatile oil levels, 55°-Brix concentrates were cut back to 43° Brix with single-strength juice. When the reconstituted juices had oil levels below 0.005%, their flavor intensity was no greater than when similar oil levels were obtained using trapped oil. Therefore, it would appear that flavor fortification with single-strength cut-back juices depends primarily on the amounts of volatile oil they add to the final product. This would suggest that other sources of volatile oil might be substituted in place of cut-back juices for flavor fortification of concentrates.

Since trapped oil fractions have been shown to be one source of concentrated orange flavor, their use would depend on the development of a practical means of recovery in place of the cold traps used experimentally. Keller *(7)* has developed such a method for citrus oil recovery, employing a refrigerated brine absorber. The absorbent is a hygroscopic brine, which removes water in the residual vapors from the cold-surface condenser and at the same time provides a cold surface upon which the volatile oils are condensed. These relatively insoluble oils can then be separated mechanically and returned to the concentrate.

Further research is in progress on the usefulness of these recovered oils for flavor fortification of concentrates.

SOURCES OF VOLATILE OIL IN ORANGE JUICE

As a result of these studies, the question arose regarding the origin of the volatile oil present in orange juices. Blair, Godar, Masters, and Riester *(2)* and Boyd and Peterson *(3)* reported that the flavor of orange juice is due entirely to oil from the peel. Davis *(4)* has demonstrated that oil is present also in the juice sacs.

To determine the source of volatile oil in orange juice, oil analyses were made on samples extracted from fruit carefully peeled to eliminate contamination with peel oil. Similar analyses were made on hand-extracted juice

from unpeeled fruit. The former juices had recoverable "pulp" oil contents as high as 0.004 to 0.006%, whereas the latter had recoverable oil contents of 0.008 to 0.012%. These results would, of course, vary somewhat with the condition and maturity of the fruit. From these oil analyses, it would appear that approximately 50% of the recoverable volatile oil present in the latter juices consisted of peel oil, while the remaining 50% must have originated in the juice sacs. Most commercially extracted single-strength orange juices, not including those used for cutback purposes, have oil contents in the range of 0.008 to 0.014%.

On the other hand, the oil contents of samples of commercial cut-back juices were found to vary from 0.04 to 0.08%. On the basis that orange juices contain around 0.005% "pulp" oil, the volatile oil in the above cut-back juices must have contained from 88 to 93% peel oil. The use of cut-back juices of even higher oil contents is anticipated by the industry, and thus such juices will necessarily contain even higher percentages of peel oil. In California, citrus reamers have been redesigned to produce cut-back juices of higher oil content than were previously used, and in some cases juices are evaporated to concentrations higher than 55° Brix in order to add more cut-back juice.

On the assumption that peel oil is the major component of the volatile oil fraction of cut-back orange juice, the possibility exists that a good grade of commercial peel oil might be substituted for the cutback juice as a means of restoring the flavor of concentrates.

FLAVOR FORTIFICATION WITH ORANGE OIL AND PUREE

To test the possibility of fortifying concentrates by substituting peel oil for cut-back juice, packs of orange concentrates were prepared in the pilot plant by evaporating juices to approximately 44° Brix, instead of the usual 55° Brix. Proper amounts of a good grade of commercial cold-press peel oil were then added for flavor restoration. In most cases, sufficient oil was added so that the reconstituted juices made from these concentrates contained an average of 0.01% oil. Adequate care was necessary to insure uniform distribution of oil throughout the concentrate. In these experiments, the most commonly used method was to mix the oil with a portion of the concentrate and blend this into the entire batch. Samples prepared in this manner were taste-tested and found comparable in flavor to samples similarly prepared with the volatile oil fractions collected in the cold traps. In this respect it is of interest to note that the oil trapped during the concentration of the juice from the peeled fruit, representing oil entirely from the pulp, proved comparable (v/v) to trapped oil similarly obtained from unpeeled fruit in restoring flavor to the concentrate. Not all lots of peel oil tested gave satisfactory flavor concentrates, and therefore, care must be exercised in the selection of a good grade of oil. Reasons for variations in lots of orange oil are being investigated.

Orange puree also was tested as a source of orange flavor and aroma for fortification of concentrates in place of cut-back juice. This product, described by Beavens *(1)*, is a rich source of peel oil. It is prepared by crushing or slicing the whole fruit and passing it through a mechanical screening device to remove the seeds, fiber, and some of the peel. The yield of puree from the whole fruit is approximately 50 to 60%, and it contains 0.5 to 0.7% oil. The following example illustrates how orange puree was used to fortify the flavor of concentrates: One gallon of orange puree containing 0.7% oil was added to 27 gallons of a 46° Brix concentrate, reducing it to 43° Brix. Reconstituted juices from this concentrate were comparable in flavor with those samples fortified with commercial peel oil.

Over 34 lots of orange concentrates fortified with peel oil and puree were produced under pilot plant conditions during the 1950 California Valencia orange season. Reconstituted juices from these concentrates were taste-tested by a comparatively large group of people, including many industry representatives, and, in most cases, the flavor and aroma were described as being very good. These fortitfied concentrates have shown no significant changes in flavor after storage at 0° F. (—18° C.) for 8 months.

Orange peel oil has, of course, been used in the past in various forms as a source of flavor in the preparation of orange beverages, bases, and confections. For instance, Heid *(5)* has suggested the use of concentrated peel oil for the flavoring of pasteurized orange concentrates.

DISCUSSION

If the flavor and aroma lost during the evaporation of orange concentrates can be restored by the addition of a material rich in orange oil, several advantages might result. One of particular importance is that this flavoring material can be carefully selected to give a product of more uniform flavor and quality. In addition, the flavor intensity may also be standardized by regulation of the amount of oil added.

Since orange peel oil and puree are more concentrated sources of flavor than single-strength juices, their use would result in less dilution of a concentrate. This could result in products of higher concentrations than those now on the market, or if higher concentrations are not desired, the evaporation process could be discontinued at lower solids values than those now employed. Discontinuing the evaporation process at a lower solids value would have the advantage of increasing the rate of production of a given evaporator; since water is more rapidly removed from an orange juice when the concentration of the latter does not exceed 43° Brix than from a more concentrated juice.

If it is desirable to use single strength juice as a medium for adding fruit cells or sugar to a concentrate, it would appear that the required volume of single strength juice could be materially reduced by the use of these concentrated flavor sources. This could be done by adding the flavoring material to the cut-back juice instead of directly to the concentrate.

The findings presented in this paper suggest promising possibilities for flavor fortification of citrus concentrates, although further work is needed to evaluate these possibilities in commercial practice. The use of peel oil or puree in place of cut-back juice, or in addition to it, should be also considered from the standpoint of various governmental regulations.

SUMMARY

A study of the volatile materials evolved during the evaporation of California Valencia orange juices indicates that the volatile flavor and aroma of orange juice appear to be primarily associated with the volatile oils. A major portion of these volatile flavoring materials is lost during the evaporation process. In the single-strength cut-back juices used to restore flavor, a major portion of the relatively high oil content is derived from the peel of the fruit. Under the conditions of the experiments reported, the volatile flavor and aroma lost during evaporation could be restored by using carefully selected cold-pressed peel oil or rich sources of volatile oils such as puree, in place of the cut-back juice.

The flavor of products fortified with peel oil or puree was found to be stable at 0° F. (—18° C.) for 8 months.

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Book Review

Industrial Piping. By Charles T. Littleton, with a special chapter on "Estimating piping costs" by R. A. Dickson. 424 pages, illustrated. McGraw-Hill Book Co., New York, N. Y., 1951. Price $8.00.

This book is unquestionably a practical and valuable volume, as represented on the dust jacket, for "piping designers, pipe foremen, draftmen, and engineers." Further, as an instruction text and reference book it should be enjoyed and appreciated by the practicing chemical engineer who otherwise often has to piece together information from textbooks, manufacturers' manuals and handbooks in order to carry out a complete piping job from selection of materials through flow-sheet work and cost estimating.

The book is exceptionally well illustrated, its writing —for the most part—is not only clear but interesting and disarmingly simple. It has an abundance of tables and charts. This reviewer enjoyed particularly the painless ease with which physical theory is handled, such as in the demonstrations of flow calculations in the chapter on "Oil Piping and the Fanning Equation."

In considering this book from the stand-point of the food technologist (either the production man or the engineer), it has numerous strong points and a few limitations. It serves to review existing conventional knowledge for handling of services such as water, gas, air and steam, and in addition it presents much that is recent in alloy piping, glass and various plastics. The food industry more often than ever before is forced to be resourceful in the selection of materials, and the use of such special piping as Haveg and Saran for certain applications in food plants is not overlooked in this volume. Consider the manufacture of protein hydrolysates where acids must be piped, as well as the extensive use of SO_2 in the starch industry and in the gelatin industry.

There are certain fields of piping technology, peculiar or important to the food industry that are omitted by the author. Sanitary stainless steel tubing, fittings and valves are not treated in this volume. Although steam traps seem to be adequately covered, grease and sediment traps are not mentioned. Steam hose and water hose, just as indispensable to the dairy industry as is sanitary tubing, are not discussed. Perhaps it is expecting too much to desire such specialized treatment. The author may favor our industry in a future edition, but we should not scorn the excellent material that exists in the present volume.

Edward Seltzer.

Advances in Food Research. Volume III. Edited by E. M. Mrak and George F. Stewart. 482 pp. plus index. Academic Press, Inc., New York, N. Y., 1951. Price $9.50.

The editors have added another very excellent volume to this series. The reviews are comprehensive, timely and well-written. The book is highly recommended.

M. A. Joslyn, and J. D. Ponting, review "Enzyme-catalyzed oxidative browning of fruit products." The summarized information emphasizes the great need for further work on the chemistry of this type of pigment formation. Methods which have been suggested for preventing browning are covered fully. This chapter contains 171 references.

The review of "Physical and chemical aspects of the production, storage and utility of dry milk products," by S. T. Coulter, R. Jenness, and W. F. Geddes brings together the results of numerous scattered observations.

B. E. Proctor and S. A. Goldblith include a number of hitherto unpublished observations in their chapter on "Electromagnetic radiation fundamentals and their application in food technology." The challenge to the food technologist in charting the way to useful application is clearly presented.

A. J. Lehman and co-workers of the Food and Drug Administration have contributed a short but valuable chapter on "Pharmacological evaluation of antioxidants." The antioxidants referred to are specifically those that have been recommended for use in fats and oils. Hitherto unpublished data on acute and chronic toxicities of butylated hydroxyanisole, propyl gallate, NDGA and others are included. In passing, your re-

viewer modestly disclaims the credit given him for proposing catechol as an edible antioxidant.

The chapter on "Salmonella" by W. R. Hinshaw and E. McNeil, will find avid readers in view of the present intense interest in this large group of organisms. The authors concentrate attention on sources of infection and methods of control.

The chapter on "Reactions between sugars and nitrogenous compounds and their relationship to certain food problems" by J. P. Danehy and W. W. Pigman is a revision of a review prepared in 1945 for the Army. The "non-enzymatic browning reaction" is given most space but other reactions are also covered. The present renewal of interest in dehydrated products makes this chapter of immediate value.

Careful reviews of somewhat restricted fields of interest include "Chemical and microbial studies on sliced canned bacon," by J. A. Ulrich and H. O. Halvorson and "Certain aspects of internal corrosion in tin plate containers," by R. R. Hartwell.

R. L. D. Morse has written on "Rationale for studies of consumer food preferences." There is a clear presentation of present techniques and pitfalls, with emphasis on the need for further methodological research.

"Control of micro-organisms causing spoilage in fruit and vegetable products," by Mathilde von Schelhorn covers the effects of heat, cold, atmospheric constituents, desiccation, fermentation, addition of chemicals, and fungicidal dips and wraps.

The book is printed on good paper in readable print.

HAROLD S. OLCOTT.

AGRICULTURAL CHEMISTRY. A REFERENCE TEXT. Vol. II. Edited by Donald E. H. Frear. 588 pages. D. Van Nostrand, Inc., New York, N. Y., 1951. Cloth bound, 6¾ by 9¾ inches. Price $9.50.

Together with Volume I, these books are designed to serve as a reference text on agricultural chemistry. Volume II is devoted to the practical applications of agricultural chemistry. Its twenty-four chapters have been written by twenty-three authors including the Editor.

Four major subjects are considered.

Part I. Chemistry of major agricultural products: Seed and cereal crops, fruit and vegetable crops, forage crops, meat and meat products, milk and dairy products and eggs and poultry products.

Part II. Fertilizers and soil amendments: Nitrogenous, potassium, phosphate, and mixed fertilizers, liming materials, and minor element supplements.

Part III. Nutrition of farm animals: Dairy cattle, beef cattle, horses and mules, sheep and goats, poultry, swine, and domestic and fur-bearing animals.

Part IV. Pesticides: Insecticides, fungicides, herbicides, inventions and patents relating to agricultural chemistry, and chemurgic applications of agricultural products.

The subject matter as presented provides a broad reference text on various applications of agricultural chemistry for advanced students, agricultural workers, and individuals concerned with the production, processing, and utilization of agricultural commodities. It has been assumed that the reader has a good general knowledge of inorganic and organic chemistry. Each section is well documented and the authors have made liberal use of tables, diagrams, and illustrations. A rather complete subject index is included. The printing and general organization of the text are good.

WILLIAM B. ESSELEN, JR.

BEET SUGAR TECHNOLOGY. Edited by R. A. McGinnis. 542 pages plus indexes. Many illustrations and tables. Reinhold Publishing Corp., New York, N. Y., 1951. Price $10.00.

Since this is the first comprehensive book written in English on beet sugar technology in 44 years, it should serve as a much needed text book for that industry. It will be of especial value to the members of both the production and technical departments of all beet sugar processors. It will also be a valuable addition to university and technical libraries in all nations having a beet sugar industry.

First, a comprehensive history of the industry is presented which includes a handy chronological table of beet sugar enterprises in the United States.

The major part of the book is devoted to the production of beet sugar, which includes detailed discussions of the tare laboratory (unique to this industry), beet storage, juice purification evaporators, fuel economy, crystallization and packaging. Besides describing the various steps of the process in detail, the fundamental chemistry and basic engineering principles are both clearly presented.

Other closely related subjects to the basic process of beet sugar manufacture are adequately described; but not in as great detail as the basic process itself. Among these related subjects are:

Special sugar products; i.e., liquid sugar; bulk shipment of granulated sugar; bakers special; soft, or brown sugars. This section contains a useful chart on the distribution of specialty sugar products.

Lime and carbon dioxide production. This section is devoted chiefly to a discussion of the basic chemistry and production techniques of the Steffens Process.

Pulp driers.

Waste disposal and by-products recovery.

The boiler house.

Technical accounting and process control.

Glossary of technical terms for beet-sugar processing.

In order to prepare a text book that will adequately cover an industry, many highly specialized fields must be covered, which obviously would be beyond the scope of one man. Thirty-nine contributing authors, each a specialist in a technical field related to beet sugar manufacture, have prepared material for this book making it a reliable reference for all phases of the industry. The book was given to the technical and production personnel of the beet sugar industry for a spot check of some of the tables, both for accuracy and value. Their comments were all favorable.

In general, the book is very well prepared as to quality of printing and the subject matter is clearly and thoroughly covered. In the reviewer's opinion, this volume is a valuable contribution to the beet processing industry.

PRESCOTT R. LLOYD.

Physics and Instrumentation[a]

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The association of physicists with the instrument industry will aid in solving problems of measurement and control which will prove of great value to the food industry in analyzing and controlling products.

Physics and instrumentation today are inseparably bonded together. Physics sets as its object the ability to predict the behavior of natural phenomena with the help of a system of laws which have been derived from observation and experience. The physicist who studies mechanics, heat, electricity, magnetism, optics, and nucleonics, may easily become the instrument designer or instrument engineer using these physical laws and principles for the measurements of natural phenomena exclusive of the war horses of electrical and process instrumentation, namely, amperes, volts, watts, temperature, pressure, flow, and liquid level.

The physicist today does not usually measure the conditions under which a process takes place, those conditions such as temperature or pressure which, if held constant, should allow a product to be produced meeting all the acceptance tests required by plant inspectors or laboratory technicians. He does measure to a great extent the properties of materials, the properties which are the measurable reason for the purchase of a product. Using food as an example, one might consider a purchaser primarily interested in calorie content, flavor, color, proof, or consistency. To satisfy the user or consumer, the manufacturer should test these properties or qualities of his product, or else take a chance that the product will not gain customer acceptance through departure from preset specifications.

If the physicist measures these properties in a laboratory, he measures what has been done in the process line, perhaps minutes, hours, or days ago. If he measures on a continuous basis on the process line, then immediate control can be effected if there is a departure from the set point, or preset property or quality measurement which is desired. It is well known, that when you can measure, you can control. With continuous measurement and control, there will be no essential product loss because of time lag between time of manufacture and time of test.

To look at the use of physics in modern instrumentation, let us look at properties of materials which define product properties. The field of physics may be divided into six major classifications, with each having a group of properties, not a totally inclusive list, of interest to those concerned with process instrumentation.

1. Mechanics
   - Consistency
   - Density
   - Specific gravity
   - Viscosity
2. Heat
   - Heat of combustion
   - Heat of fusion
   - Heat of vaporization
   - Moisture content
   - Specific heat
   - Thermal conductivity
3. Electricity
   - Conductivity
   - Dielectric strength
   - Electromotive effect
   - Impedance
4. Magnetism
   - Magnetic permeability
   - Magnetic susceptibility
   - Residual magnetism
   - Mass
5. Optics
   - Refractive index
   - Sound
   - Spectral absorption—X-ray, Infrared, Visible, Ultraviolet
   - Turbidity
   - Ultrasonic absorption
6. Nucleonics
   - Fission
   - Molecular weight
   - Photoelectricity
   - Radioactivity
   - Thermionic emission
   - Transmutation

The end desire of most physical measurement is analysis. Analytical instruments are designed for quantitative or qualitative analysis, or both. Those which are qualitative in nature generally operate by one of two methods. First, a phenomenon may exist which will permit an instrument to be specific to a single element or compound, or to several different ones, provided only one can possibly be present at one time, namely, that for which the instrument is calibrated. Secondly, a plot may be drawn of total property measurement against, for example, wave length or mass number. In such a case, the curve is compared with curves of pure compounds, and a determination is made of those compounds which contribute to the curve being analyzed. Thus may composition be determined.

To determine quantitative analysis through the measurement of a property, all the components must be known qualitatively, and there must, in general, be a known relationship between analysis and the actual property which is measured. With a known relationship, a scale can be calibrated in specific concentration, sometimes of one component. By picking the proper physical property to measure, one can sometimes get greater selectivity than is implied here. It should always be recognized that these quantitative measurements based upon one property are only valid and only good until an unknown impurity is introduced.

[a] Presented at the Eleventh Annual Meeting of the IFT, New York, N. Y., June 20, 1951.

Let us look at specific instrument examples. A combustibles analyzer *(8)* measures the heat of combustion or the calorific value of a gas. One arm of a four-arm wheatstone bridge is a platinum filament operated at red heat. Combustible gas when mixed with air or oxygen will burn on this filament. The temperature rise of the filament due to the burning gas is dependent upon the composition of the gas. Therefore, a varying composition means a varying temperature and a varying resistance of the filament, causing a bridge unbalance with the bridge current output able to be indicated or recorded and interpreted as an analysis of the gas stream.

An excess of air or oxygen will permit combustible gases such as hydrogen, carbon monoxide, and hydrocarbons, either singly or combined, to be measured. Conversely, if an oxygen-laden gas is burned with an excess of synthetic organic fuel, then oxygen concentration can be recorded instead of combustibles concentration.

The thermal-conductivity analyzer *(3, 4, 8)* is circuitwise, similar to the combustibles analyzer. The filament, however, is operated below 400° F. (204.5° C.) so that the gas passing over it does not burn but carries away heat from the filament, depending upon the thermal conductivity of the gas itself. The reference cell gas is chosen with a composition generally the same as the gas composition at some point on the instrument scale range, normally one of the ends. With a constant rate of energy supplied to the filament, the temperature which the wire assumes in the cell varies inversely with the thermal conductivity of the gas surrounding the filament.

A dewpoint recorder *(3, 10, 11)* is based upon the well-known principle that the temperature of a surface on which moisture will just condense from the gas passing over it is the dewpoint temperature of the gas, and is directly a function of the absolute humidity of the gas. The temperature of the surface is recorded by a thermocouple-actuated recorder. A measured gas flow passes over a mirror surface, which is continuously cooled by a refrigerator to the lowest measurable dewpoint temperature. A small heater behind the mirror has its current regulated so that it may raise the temperature from the lowest to the highest measurable dewpoint temperature with the refrigerator still in operation. The heater current is proportioned so that the mirror will just show a minute formation of dew through an optical system of a light source and phototube. The output of the latter through an amplifier and thyratron control proportions the heater current. In actual practice, the system will slowly cycle between dew and no dew with a maximum cycle amplitude of 2° F.

A measurement of conductivity under appropriate conditions is a measurement of moisture content. It is a known fact that as the temperature of a hygroscopic salt rises, it loses water to the atmosphere. There will always be a temperature at which the vapor pressure of the water in the salts equals the partial pressure of the water in the atmosphere. This is an equilibrium point, and its temperature may be considered as a function of the moisture content of the atmosphere.

If a cylinder is coated with lithium chloride with a dual electric winding embedded in it, the salt may be heated by passing current through the salt from the dual winding *(3)*. Since the salt conductivity changes with its water content, the salt automatically regulates the flow of electricity such that equilibrium temperature is maintained. The resistance-bulb actuated recorder can be calibrated in moisture content units.

The measurement of impedance by a metal detector is a basis for the inspection of food products for unwanted metal. A coil assembly of four coaxial windings may be built with the windings rigidly grouped in pairs to form two adjacent air-core transformers. The primaries are connected to a constant frequency a-c source provided by the control unit. The secondaries are connected in opposition and under normal conditions are balanced to give a zero output at the electronic unit. Passage of metal through the coil upsets the voltage balance between the two transformers with the resultant unbalanced voltage generated by a change of impedance in the coils being used as an alarm for unwanted metal. Such a metal detector as described may operate on a change of impedance or inductance of one part in 400,000, requiring some special precautions for any factor that could affect impedance measurement.

Except for the oxides of nitrogen, oxygen is the only gas that is paramagnetic or able to pass magnetic flux more easily than a vacuum. Oxygen permeability in itself is extremely low, but is sufficient to permit analysis by virtue of this specific magnetic property *(3)*. The electrical circuit is that of a thermal conductivity analyzer. The two thermal conductivity cells are in series with the oxygen-laden gas which diffuses into both. A large permanent magnet places an inhomogeneous magnetic field across one cell. Oxygen is attracted to the center of the cell along the hot filament where the heating of the oxygen causes the gas to lose its magnetic properties in proportion to the square of the absolute temperature. The heated oxygen, whose magnetic susceptibility becomes lower, is forced out of the magnetic field by the cooler oxygen. The oxygen forced out of the field cools itself on the cell wall and re-circulates. The amount of re-circulation is a function of the oxygen concentration and is measured by the filament cooling and consequent bridge unbalance.

A mass spectrometer *(1, 3, 9)* separates gas molecules within a high vacuum according to their mass by ionizing the gas, accelerating the ions, and deflecting them in a magnetic field. Variation of the ion accelerating potential with a fixed magnetic field, or vice-versa, permits ions of different specific mass to be focused in turn at a collector slit. A controlled variation in magnetic field strength, therefore, permits a mass spectrum to be drawn by recording collector current and, therefore, mass abundance as the magnetic field is swept across a mass number range of one to three hundred or more.

A mass spectrometer permits qualitative as well as quantitative analysis and is frequently considered as the master analytical instrument in existence today. Since the complex molecules of a chemical compound are struck by ionizing electrons, they are dissociated into

all possible fragments. All compounds have molecular fragmentation patterns. Experience with qualitative analysis of various fragmentation patterns enables one to make reliable estimates of the primary constituents in an unknown mixture.

The field of optics has widespread use in instrumentation. In the field of spectral absorption, X-ray, infrared, visible, and ultraviolet are all being used and are giving reliable and valuable data. Somewhere in the electromagnetic spectrum, practically all substances possess a selective absorption which can be used as a positive identification, even in the presence of many other materials. If the wave length of the radiation passing through a material varies, the received radiation when measured and recorded gives a spectrum generally characterized by a series of peaks and valleys, which may be used for both quantitative and qualitative analysis *(6)*. Wtihout regard to the particular area within the electromagnetic spectrum, the many instruments operate generally on the principle of total absorption measurement, or spectral scanning with a monochromatic source and a receiver sensitive to a large span of the spectrum. Total absorption instruments are generally associated with quantitative analysis, while the monochromatic scanners are associated with qualitative and quantitative analysis. The photoelectric spectrophotometer operating in the visible range from 4000 to 7000 A. is an analytical tool, though it is generally associated with color measurement. A light beam is dispersed, passed through a monchromator, collimated, and then is passed through a polarizing and pulsing optical system into an integrating sphere where it falls alternately 60 times a second on a sample and a standard. A difference in reflected light between the standard and the sample will, through the phototube, amplifier, and motor drive, rotate a rochon prism to change the light intensity on the standard till the reflectances are equal. The position of the rochon prism is recorded against wave length and becomes the color spectrum of a sample.

Every food manufacturer knows the misfortune of having metallic or other particles in food. An X-ray beam or beams may pass through food samples onto a fluoroscope permitting an operator, through use of a viewing screen, to look at packages or other containers of food as they pass under the beam and to remove those which have foreign matter in them. Actual X-rays will show stones and dirt in peanuts, pieces of glass or wire in candy, chipped bones in meat, foreign materials in breakfast cereals, or actually show, in certain cases, good from bad food. The operating principle is very simple. The absorption of X-ray varies with the material in its path. Foreign particles in food products reduce the transmission and thus show up as dark spots on the fluoroscopic screen.

The simplest form of an infrared analyzer *(2, 3, 7)* is a double beam instrument operating on a total absorption principle. A globar provides a source of infrared radiation. The beam is divided and each beam then impinges on its own bolometer receiver. The difference between the radiation reaching the two bolometers is recorded and is interpreted as the quantitative analysis of a gas or liquid.

In operation, a stream of dry gas at constant pressure is passed through the sample cell which covers both beams. Thus, infrared energy in any but the desired absorption band affects both beams equally and causes no unbalance of the bridge circuit. One beam only is covered with a cell containing a very high concentration of the gas whose concentration is to be recorded. This high concentration effectively absorbs all the radiation associated with the particular gas so that variations in the other beam, when compared with the so-called standard beam, will affect the bridge circuit. Thus, the bridge is unbalanced by a differential in energy reaching the bolometers. When mixtures become complex and absorption bans overlap each other, then interference cells can be introduced which will filter out the absorption due to certain gases, so that the eventual energy reaching the bolometer is strictly the differential based upon the gas whose concentration is to be recorded.

In the original tabulation, we grouped together certain phenomena associated with nucleonics, not in the sense of present day newspapers which are concerned with the subject, but in the broad general sense of physics. It has been found experimentally that the positive ion emission from a heated platinum surface is changed in the presence of halogen compounds. Halogens, as you know, are the compounds of fluorine, chlorine, bromine, and iodine. Positive ion emission is unchanged in the presence of most other common gasses. Thus, if a platinum filament is made part of a diode, a bridge circuit change in diode current can be interpreted as change of filament emission.

This phenomenon forms the basis for a halogen leak detector *(5)*. In practice, a tank, for example, may be filled with a very slight concentration of a halogen compound such as carbon tetrachloride or freon. A probe is passed over those areas suspected of leaking, and any gaseous halogen out-leakage from the tank, caused by a differential in pressure between the inside of the tank and the outside at atmospheric pressure, is essentially passed across the platinum surface. Thus, wherever there is a positive indication of halogen ions, then there is a leak underneath the probe. This detector is so sensitive that it will detect a leak so small that in one year only 1/100 of an ounce of freon will pass through the leak opening.

The instrumentation associated with the measurement and control of properties of material is in its infancy. It will grow as physicists continue to associate themselves with the instrument industry. The food industry is often considered as under-instrumented. Its problems are welcomed by instrument men everywhere. The physicist with sound knowledge of the fundamentals of all physical laws can help.

SUMMARY

The purchaser of a food product is interested in specific properties which the manufacturer must meet to gain customer acceptance. Many of these properties, now tested for after the food is processed, could be obtained by control of process variables. Modern instruments, designed for measurement of various variables, employ principles of physics in their operation. Physi-

cists in the instrument industry may aid in adapting measuring devices to control the variables of food processes.

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Radiography Applied to Grain and Seeds[a,b]

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(Manuscript received May 28, 1951)

A radiographic method for the detection of internal insect infestation in grain by means of low energy radiation from a cobalt-target beryllium-window X-ray tube is described. The utility of the technic for inspection of wheat, corn, rice, and beans is illustrated with cuts made from original radiographs.

The presence of insect fragments in flour and other granular foods has long been a major problem in industries which process grain or seeds. Such fragments occur because various insects deposit their eggs in or on the seed. The offspring may spend a portion of their life cycle within such materials and their detection or removal prior to processing of the grain or emergence as adult forms, until now has been virtually impossible.

The Food and Drug Administration has formulated and enforced rigorous standards to assure the freedom of such products from insect fragments. At one time it was believed that inadequate sanitation practices in the manufacturing plants of these industries were contributing factors to insect fragments and filth in the products. The recent report of the Food and Drug Administration *(4)* dealing with the relationship of the degree of internal infestation in wheat to fragments in the milled products of a number of commercial flour mills, indicates conclusively, however, that internal infestation in the grain received by the mill, rather than external filth is the major source of fragments in commercial granular cereal products. While the results of this survey of the Food and Drug Administration were generally anticipated, the fact remains that in the official grain standards of the United States under which all grains are bought and sold, no recognition exists of the extent to which internal infestation may influence processing quality of grain or the sanitary characteristics of the products. All suggestions that such standards should be modified in order to provide adequate discounts or penalties for infested grain have been met with the retort that until there is developed a method for detecting internal infestation, simple and rapid enough for use at any inspection point where grain is marketed, little can be done to segregate or discount internally infested commercial grain.

This problem has prompted studies now in progress at Kansas State College aimed at developing methods for the positive identification and quantitative determination of internal insect life and damage in commercial grain. The present report deals with an application of X-ray radiography, which appears to hold considerable promise for the inspection of many kinds of seeds. The utility of the method for wheat has been shown in previous reports *(1, 3)*.

PROCEDURE

Preliminary studies were carried out on infested grain selected by using a presumptive test for infestation *(2)* and utilizing a medical X-ray unit operated in conventional fashion. Poor results were obtained, confirming the experience of other workers in this field who had attempted radiography with this type of apparatus. However, when the technics of industrial radiography were applied, more positive results were obtained.

A cobalt-target Machlett X-ray diffraction tube equipped with a beryllium window was found to be a satisfactory source of low energy radiation. This tube was operated at currents ranging from 6 ma. at 12 kv. to 10 ma. at 30 kv., with various exposure times ranging from five seconds at the highest voltage to 3 minutes in the lower range of voltage. Eastman type A industrial X-ray film, which is of high contrast and fine grain, was found ideal. The manufacturer's recommendations for the processing of this film were observed. A major factor in obtaining clear radiographs showing good differentiation of insects within seeds is the presence of a minimum amount of absorbing material between the seeds and the film because the type of radiation used is so readily absorbed and scattered by even relatively permeable materials. In the present studies standard cardboard X-ray film holders were modified by cutting away a rectangular section of the cardboard face and replacing it with a sheet of thin photographic black paper to protect the film from light during manipulation and exposure of the film to X-ray. In some cases it was necessary to maintain the film holder in a vertitcal position, since the cobalt-target X-ray

[a] Contribution No. 198, Department of Milling Industry and Contribution No. 12, Department of Physics, Kansas State College, Manhattan, Kansas. This research was supported by a grant from The Millers' National Federation, Chicago, Illinois.

[b] Presented at the Eleventh Annual Meeting of the IFT, New York, N. Y., June 18, 1951.

diffraction tube was permanently mounted and the beam emerged horizontally. In such cases the samples to be examined were attached to the photographic black paper by means of rubber cement. Satisfactory radiographs have been obtained with cobalt, copper, and molybdenum targets when the excitation voltages were low enough and provided the tubes were equipped with a beryllium window to transmit soft X-rays. Tungsten targets also, doubtless, would be suitable. More complete details of the technic have been published *(1, 3)*.

Insects at various stages of growth were readily detected in the following materials: wheat infested with rice weevil, granary weevil, and Angoumois grain moth; corn containing rice weevil and Angoumois moth; rough rice and milled rice infested with rice weevil; cowpeas infested with common bean weevil and southern cowpea weevil; and pinto beans and kidney beans infested with common bean weevil.

RESULTS AND DISCUSSION

The photographs and radiographs of seed samples in Figures 1 to 4, although showing considerable loss of clarity in comparison to original prints due to reproduction, indicate the utility of the technic and are representative of numerous examinations which have been made. Studies are in progress to develop rapid sampling and inspection methods in order to render the technic suitable in commercial practice for the inspection and market grading of all major seed crops. It seems possible that the test will find a place beside the protein test for wheat as a test for quality auxiliary to the United States Grain Standards.

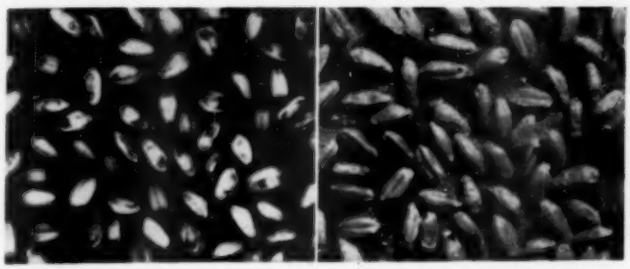

Figure 1. Left, radiograph of wheat containing rice weevil at various stages of development 22 days after infestation. Larvae, pupae, and adult stages are apparent. No emergence of insects had occurred at this stage. Right, ordinary photograph of the same sample of wheat shown, 40 days after exposure to rice weevil, when insect emergence was virtually complete. Note that no external indication of internal infestation appears until insect emerges.

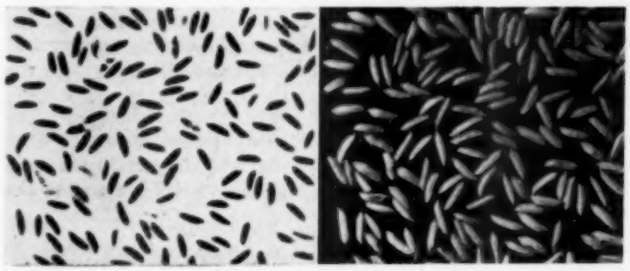

Figure 2. Left, radiograph of rough rice showing internal infestation by rice weevil, also cracked grains. Right, ordinary photograph of the same grain as in field on left. Internal infestation and cracked grains are invisible.

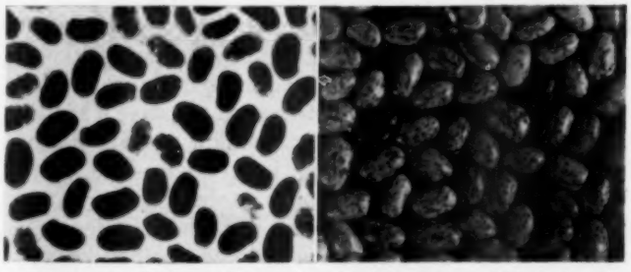

Figure 3. Left, radiograph of pinto beans infested with common bean weevil. Right, ordinary photograph of the same sample.

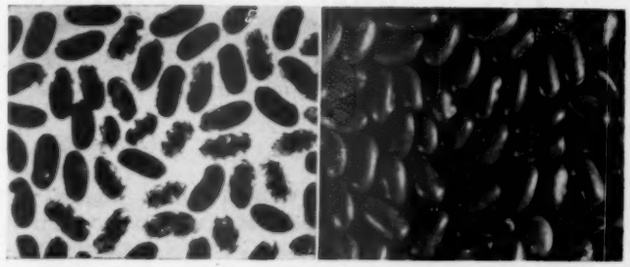

Figure 4. Left, radiograph of kidney beans infested with common bean weevil. Right, ordinary photograph of the same sample.

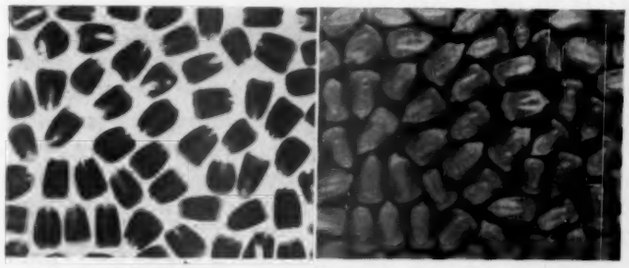

Figure 5. Left, radiograph of corn infested with Angoumois grain moth. Right, ordinary photograph of the same sample.

SUMMARY

For the detection of internal insect infestation in grain, low energy radiation from a cobalt-target beryllium-window X-ray tube was found ideal. The presence of a minimum amount of extraneous material between the seed specimen and film as well as the use of fine-grain industrial X-ray film facilitated the production of detailed radiographs showing clearly internal insect infestation at all stages of development, as well as the extent of internal loss of grain kernels due to insect feeding. The utility of the technic for inspection of wheat, corn, rice, and beans is illustrated with cuts made from original radiographs.

Acknowledgment

We wish to acknowledge the assistance of Mr. J. C. Frankenfeld, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, in procuring for us various samples of internally infested seeds, and the kindness of the Picker X-Ray Corporation of New York, N. Y., in loaning us certain equipment used in these studies.

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The Quality of Sauerkraut Preserved in Tin and Glass[a]

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(Manuscript received July 11, 1951)

The scarcity of tin during recent years has reduced the tin allotments to the food industry. Many food processors have found it necessary to use glass containers for products previously packed in cans. The effect, therefore, of the container on the quality of the product is of interest to food processors. In the work reported here, the quality of sauerkraut packed in tin and in glass is compared.

Definition of quality of sauerkraut is different since individual opinions differ markedly and the character of the product is variable. To eliminate the personal element and present results in figures that can be compared from year to year, objective methods for measuring the quality of foods are essential. An attempt was made in previous studies *(3, 4)* to correlate certain measurable factors with quality. Correlations were observed between soft texture and abnormal salt concentrations, and between abnormal quality and total acid, volatile acid, alcohol, salt, and to some extent ascorbic acid. Since then, many of the conditions that have caused these abnormalities have been corrected in commercial practice. The majority of quality defects now prsent in canned kraut are caused by improper temperature conditions during fermentation, processing, and storage, rather than by other factors, such as improper salting and poor covering of vats. The effects caused by heat are not measurable by the above chemical determinations.

In a recent survey of commercial canned kraut *(5)*, the above determinations have been made as in the previous studies *(3, 4)* and in addition the kraut has been scored on the basis of the Federal PMA grading system generally used by the kraut industry. In the first series of 16 samples examined, a close relationship was noted between color and flavor. Therefore, it was felt that, if color could be measured objectively, the measurement would give an indication of quality of those krauts that were not normal because of improper salting, surface fermentations, and similar causes.

The color of kraut will depend on numerous factors. An ideal white head of cabbage will yield a white kraut with a faint green tint when fully fermented. Green leaves will remain green for some time. As kraut ages, the green shreds turn yellow to brown. With increasing age the white shreds will also turn yellow to brown. Overheating will produce similar color changes. The color of good kraut is sometimes defined as a "light straw color," but opinions differ in interpretation of the term "light straw color." Kraut will become pink due to action of certain yeasts, it will darken due to exposure to air and it may discolor by other means. An objective method of measuring the color of kraut should aid in defining these color defects.

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The Hunter Color Difference Meter *(2)*, a recently developed photoelectric instrument, determines color by reflectance measurement. The instrument records R_d (or L), *a* and *b* readings, which correspond to brightness, redness, and yellowness, respectively. Negative *a* and *b* readings indicate greenness and blueness, respectively. From these, the Munsell system dimensions of hue, chroma, and value, or the International Commission on Illumination (I.C.I.) dominant wave length, purity, and brightness may be calculated. In the work reported here, the Hunter Color Difference Meter has been applied to measure the color of sauerkraut.

EXPERIMENTAL METHODS

Color measurements had been made of 152 of the 168 samples of commercial krauts that were graded in a recent survey. They were first sampled for chemical analysis, and then graded for color, cut, defects, crispness and flavor. These results were so enlightening that the instrument was also used to study effects of heat upon kraut in tin and glass, and effect of heat of processing and storage upon canned kraut.

For the sauerkraut readings, the R_d scale was used with large area illumination. This arrangement views a circular area of kraut 2¼ inches in diameter. The sample container, made of optical-quality Plexiglas, was constructed by using 2⅜ inch Plexiglas tubing to make a cylinder 2½ inches high. A 3½ inch square of flat Plexiglas was joined to the bottom of the cylinder with a cement made by dissolving shavings of the material in acetone. The cells were firmly packed with sauerkraut. Since color variations occur within individual cans, three cells were packed from each can to be measured and the average was computed.

The standard tile used for setting the instrument was the National Bureau of Standards Kitchen and Bathroom tile No. 31. This greenish yellow tile had R_d, *a*, and *b* values of 58.1, −1.1, and 24.5, respectively. The reflectance spectrum of the tile was first measured on the Beckman Spectrophotometer and the I. C. I. values were calculated from the resulting curve by the 30 selected ordinate method *(1)*. The results were: X, 0.5648; Y, 0.5810; Z, 0.3722; dominant wave length, 576.6 mμ; and purity, 34.5%. The *a* and *b* readings were then calculated from these *(2)*. The R_d reading of the standard plate is higher than the sauerkraut range, but the *a* and *b* readings are within the range of Grade A sauerkraut.

RESULTS AND DISCUSSION

Comparison of Hunter *a* readings with color ratings (Figure 1) shows good correlation in the case of the majority of samples, considering the variability of different samples of kraut and the human element in grading (r is −0.75). In the sauerkraut color region, the hue is largely determined by the *a* reading, although an exact calculation of hue would require corrections for *b* readings and for brightness. A negative *a* reading is associated with green color, while a positive *a* reading is obtained as browning progresses. The R_d, or brightness readings, show some interesting correlations which will be discussed later. In the Hunter color system, chromaticity (analogous to Munsell chroma) is represented by $(a^2 + b^2)^{1/2}$. Since, for sauerkraut, *a* approximates only ± 2.0 while *b* is usually about 20,

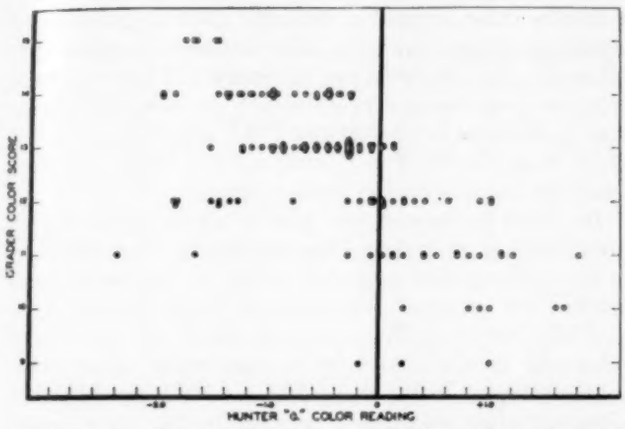

Figure 1. The relation between grader color score and Hunter a reading for commercial processed sauerkraut. (Samples containing excessive green shreds are indicated by cross-hatched circles; samples showing yeasty fermentation by solid circles.)

it can be readily seen that the *b* reading largely determines chromaticity. The chromaticity of sauerkraut was found to have no effect on the grade except in the case of one sample described as "washed out," where the *b* reading was exceptionally low.

As shown in Figure 1, the majority of the samples given grader color scores of 13 and 15 yielded Hunter *a* readings between 0 and —2.0, while the majority of the samples given color scores of 12 or lower yielded Hunter *a* readings from 0 to +1.8. Omitting a few samples which were obviously out of line for other reasons, a correlation of —0.75 was observed between Hunter *a* readings and grader color scores. Among the several samples out of line, that is, those rating lower than the Hunter *a* scores would indicate, all except two were rated low because of excessive green shreds. This is a matter of grader opinion but an important one. Perhaps excessive green shreds should be scored under "absence of defects" rather than under color quality. The two out-of-line samples which were not green showed a yeasty fermentation and were dull rather than glossy in appearance. Such samples would be rejected because of flavor and texture.

Further analysis of the data shows that a majority of samples which were rated low in color were relatively dark, indicated by a low R_d reading. The 9 samples that gave a color rating of 10 or lower, yielded an average R_d reading of 22.4 and ranged from 20.4 to 26.6. The 19 samples given a rating of 11 averaged 25.6, and ranged from 22.5 to 29.5; and the 27 samples given a rating of 12 averaged 26.4 and ranged from 21.4 to 30.4. Only 6 of the 93 samples rating 13 or above yielded an R_d reading below 25.5. The majority ranged from 26.5 to 33.4 and averaged 28.6. Thus the krauts given poorer ratings on the basis of color are generally less bright in appearance. Even most of those green samples that yielded a Hunter *a* reading between 0 and —2.4, but were graded 12 or lower because of excessive green shreds, were less bright, and yielded an R_d average of 26.3.

From these observations it seemed that brightness as well as *a* value, or hue, might have an effect in determining the color grade. A correlation between color grade and the two factors, R_d and *a* for the 152 samples yielded a correlation coefficient (R value) of 0.78. Prediction of the color score for the R_d and *a* readings may be achieved by the following regression equation:

$$\text{PMA color score equals } 9.5 - 1.12\,a + 0.10\,R_d.$$

The equation calculated here is based on one individual's judgment. It must be emphasized that this particular formula is not recommended for prediction of color grade. Such a formula should be developed by a trained panel of observers using many more samples.

Consideration of the equation shows that the *a* readings which can vary from —2.0 to +2.0 can contribute a range of about four points to this color score. The R_d range varies from 20 to 30, which means that a bright kraut can get one more color point than a dark kraut, regardless of hue. Hence the *a* reading may carry four times as much weight as the R_d value. Partial correlation coefficients for *a* and R_d are —0.70 and +0.30, respectively.

A fair correlation ($r = -0.64$) was obtained between flavor and color (Figure 2). However, some of the

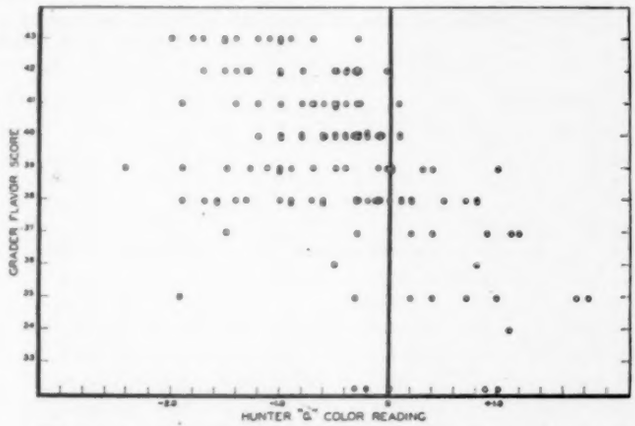

Figure 2. The relation between grader flavor score and Hunter a color reading.

green-colored krauts rated low in flavor as well as color, and there were a few samples that were faulty in flavor from other causes; one was benzoated, three had marked flavor of secondary surface fermentation, and a few were woody in flavor.

Storage Tests in Tin and Glass

An accurate method of determining color and flavor change of kraut where the changes are due to heat made it possible to determine the effect of various storage temperatures upon kraut in glass and tin. Changes due to stacking in the warehouse were also measured.

Several cases of kraut were packed in tin and in glass in a kraut factory from a single vat of kraut. The canning was completed within 15 minutes. Containers were cooled quickly and uniformly in cold running water. Twelve each of the glass and tin containers were stored in constant temperature rooms at 1°, 7°, 21°, 32°, 37°, 44°, and 55° C. (33.8°, 44.5°, 69.8°, 98.6°, 111.2°, and 130.5° F.). Samples were removed at intervals during storage beginning at 3 days for high storage temperature and as long as three months later for samples stored at low temperatures. These samples were analyzed for color, ascorbic acid, salt, and total acid. A vacuum reading was taken before the containers were opened. This procedure was repeated later with a second lot of kraut (B series).

The results of the color analyses (Tables 1 and 2) show a rapid change in color at higher temperatures in both tin and glass but the change was more marked in glass. In fact, kraut packed in tin scored a point higher in color than did that packed in glass immediately after processing. Apparently the tin had a protective action on the color during processing.

Salt and acid contents were uniform in tin and glass. This indicated uniform filling. The samples in Series A averaged 1.45% acid (as lactic acid) and 1.60% salt, in Series B 1.40% acid and 1.66% salt. Containers showed vacuum readings from 13 to 19 inches. Ascorbic acid was low in both lots (Table 3). However, results show a definite destruction of ascorbic acid, corresponding to the temperature of storage. After processing, the ascorbic acid values were consistently lower in glass than in tin containers. Samples showing color deterioration graded lower in flavor.

One may observe (Tables 1 and 2) that, for kraut packed in tin, greater changes occur in a day and a half at 98.6° F. or above than occur at 33.8° and 44.6° F. in a month. The Hunter *a* readings show a progressive browning in glass and tin with increased temperature. Likewise, the R_d readings decrease. Thus, changes occur in both hue and brightness. The color deterioration is sufficient to change the PMA grading of cans of kraut from Grade A to Grade C in a matter of days when the kraut is held in stack storage.

In order to observe the relative effect upon cans of kraut stacked in storage, thermocouples were attached to the sides of cans packed in cases as they were being stacked for storage. The cans of kraut seemed quite cool after water cooling. Actually they were not cooled internally as was shown by average temperature readings of from 38.9° to 43.3° C. (102° to 110° F.) observed after stacking. The cans in the cases cooled slowly (Table 4), and five days later the temperature of the can was still as high as 31.6° C. (89° F.). The storage of the kraut under such conditions markedly affected the color of the kraut, the deterioration being proportionately greater in those cans which were cooled slowest. The kraut in the two cans which were cooled

TABLE 1

Effect of storage upon the color of sauerkraut packed in tin and glass containers, as measured by the Hunter color difference meter. Series A

Temperature		Type of container	Storage time in days									
			3		6		14		30		90	
°C.	°F.		*a*	R_d	*a*	R_d	*a*	R_d	*a*	R_d	*a*	R_d
1	34	Tin	−0.5	28.0	−0.6	27.4	.....	.....	−0.3	28.9	−0.6	27.6
		Glass	−0.2	26.0	0	27.1	.....	.....	+0.1	26.9	+0.3	25.5
7	45	Tin	.....	.....	0	27.6	.....	.....	−0.5	28.5	−0.5	27.9
		Glass	.....	.....	+0.1	26.7	.....	.....	+0.4	27.1	+0.3	25.8
21	70	Tin	.....	.....	−0.5	27.4	.....	.....	−0.3	28.1	−0.4	27.5
		Glass	.....	.....	+0.1	26.4	.....	.....	+0.2	26.3	+0.8	24.4
32	85	Tin	.....	.....	−0.3	26.7	−0.3	26.6	0	27.6	+0.4	26.1
		Glass	.....	.....	+0.4	25.0	+0.7	25.0	+1.4	23.6	+2.1	22.5
37	98	Tin	−0.4	26.5	+0.2	27.0	0	26.1	+0.5	26.1	+1.2	24.1
		Glass	+0.3	25.3	+0.9	24.3	+0.9	24.3	+1.6	22.7	+2.3	20.9
44	110	Tin	+0.3	26.1	+0.2	26.3	+0.3	24.9	+1.5	24.2	.....	.....
		Glass	+0.8	24.4	+1.1	24.1	+1.2	23.2	+2.2	20.2	.....	.....
55	130	Tin	+0.5	25.4	+0.3	25.2	+1.1	22.8	+2.2	20.6	.....	.....
		Glass	+1.2	23.4	+1.4	22.6	+2.2	20.0	+2.5	17.3	.....	.....

TABLE 2

Effect of storage upon the color of sauerkraut packed in tin and glass containers, as measured by the Hunter color difference meter. Series B [b]

Temperature		Type of container	Storage time in days									
			1½		4		7		14		28		60	
°C.	°F.		*a*	R_d	*a*	R_d	*a*	R_d	*a*	R_d	*a*	R_d	*a*	R_d
1	34	Tin	.....	.....	.....	.....	0.3	29.0	0.3	29.2	0.5	29.0	0.7	29.0
		Glass	.....	.....	.....	.....	0.6	27.7	0.7	28.3	1.1	26.9	1.2	27.9
7	45	Tin	.....	.....	.....	.....	0.5	28.1	0.6	28.6	0.5	29.3	0.7	28.5
		Glass	.....	.....	.....	.....	0.6	28.5	0.7	27.3	1.2	27.3	1.2	27.1
21	70	Tin	.....	.....	.....	.....	0.5	27.7	0.5	28.2	1.3	28.4	1.1	26.8
		Glass	.....	.....	.....	.....	0.8	27.0	0.9	26.4	1.8	27.0	2.3	24.4
32	85	Tin	0.4	28.2			0.9	28.0	1.0	26.9	1.9	27.7	1.8	25.4
		Glass	0.9	27.0			1.5	26.1	1.6	26.0	2.8	25.0	3.2	21.5
37	98	Tin	0.6	27.5	0.9	27.6	1.4	26.7	1.4	27.0	2.0	26.0	2.1	24.3
		Glass	1.0	26.6	1.5	26.6	2.2	24.6	2.3	24.6	3.1	23.7	3.9	20.1
44	110	Tin	0.8	27.9	1.3	27.2	1.4	26.5	1.3	26.8	2.6	24.8	3.2	21.7
		Glass	1.3	26.1	1.9	24.9	2.1	24.7	2.2	23.2	3.3	22.1	.....	.....
55	130	Tin	1.3	27.2	1.4	25.8	1.6	24.5	2.6	22.4	4.1	20.6	4.0	19.0
		Glass	1.9	24.9	1.8	23.6	2.6	22.8	2.9	20.0	4.2	17.5	.....	.....

[b] All values for *a* in this table are positive.

TABLE 3

Effect of storage on the ascorbic acid content of sauerkraut packed in tin and glass containers [a]

Temperature		Type of container	Days in storage										
°F.	°C.		6	8	14	30	90	1½	4	7	14	28	60
					Series A					Series B			
34	1	Tin	8.8	.....	.....	8.7	9.2	.....	.....	10.3	10.0	8.9	10.3
		Glass	6.6	.....	.....	6.1	5.5	.....	.....	8.2	8.3	6.4	7.8
45	7	Tin	8.9	.....	.....	9.0	9.3	.....	.....	9.6	9.7	9.4	9.8
		Glass	7.1	.....	.....	6.2	5.4	.....	.....	8.2	7.3	6.2	6.5
70	21	Tin	9.1	.....	.....	9.7	9.3	.....	.....	10.0	9.8	9.4	9.0
		Glass	7.0	.....	.....	7.6	7.2	.....	.....	7.9	7.8	6.4	6.6
85	32	Tin	9.2	.....	8.7	9.0	7.7	9.7	.....	9.2	9.7	9.4	8.0
		Glass	5.0	.....	4.9	4.9	5.8	6.6	.....	6.4	6.9	6.4	4.9
98	37	Tin	9.3		8.1	8.7	5.9	9.3	9.1	9.6	8.6	8.7	8.4
		Glass	5.2		4.9	4.9	3.9	7.7	7.3	6.2	6.2	6.2	5.4
110	44	Tin	9.0	8.2	8.4	8.8	.....	9.7	9.0	9.6	8.5	9.0	8.5
		Glass	6.8	4.8	4.8	4.4	.....	7.2	6.3	6.5	5.5	6.0	.....
130	55	Tin	9.2	8.6	8.5	10.5	.....	8.6	8.7	8.0	8.1	8.5	9.0
		Glass	5.6	5.1	4.6	3.0	.....	7.1	6.4	5.9	4.7	4.4	.....

[a] Ascorbic acid content expressed as mg. per 100 g.

TABLE 4

Temperature changes in canned sauerkraut immediately after being placed in storage

No.	Location of Thermocouple in stack [d]			Temperature ° F. after hours indicated								Average Hunter color readings [e]		
	Height	Depth	In case	0	1	6	23	31	52	77	124	R_d	*a*	*b*
8	3	5	Center	108	110	109	106.5	103.5	99	92.5	83	27.2	+0.5	18.6
9	3	1	Outside	102	103	93	83	82	77.5	71	66	27.5	+0.5	18.2
10	3	1	Center	102	104	104	97	93.5	87	81	77	28.0	+0.4	19.0
4	7	5	Center	106	108	106.5	107	103	102	96	89	26.6	+1.0	18.5
3	7	5	Outside	94.5	104	106.5	107	103	102	96	89	26.7	+0.9	18.5
2	7	1	Outside	102	107	102	95	88.5	86.5	78	72	27.8	+0.5	18.5
1	11	3	Center	95	108	107.5	104	98	94.5	88	80	27.4	+0.4	19.3
0	13	1	Outside	92.5	102	106.5	89	85	81	73	67	27.5	+0.3	18.6

[d] Height, number of cases from bottom of stack; depth, number of cases from outside; in case, location of thermocouple in case.
[e] Original kraut: R_d, 28.7; *a*, −0.2; *b*, 18.0.

slowest showed a change from the original −0.2 *a* to +0.9 and +1.0 *a*. The original 28.7 R_d reading changed to 26.7 and 26.6 in five days. These results indicate a marked change in hue as well as brightness. The PMA color grading dropped from Grade A to Grade C.

SUMMARY

A comparison between total acid, salt, ascorbic acid, and Hunter color values and ratings made according to the Federal PMA scoring system for color and flavor was made upon 152 samples of commercially processed sauerkraut. The effect of storage temperatures and time upon two lots of commercial kraut packed in glass and tin was measurerd. Further, a study was made of the rate of cooling of commercially canned kraut stored in the warehouse and of the effect of heat on color.

The Hunter Color Difference Meter offers an objective method of measurement of color quality of kraut.

Flavor and color scoring correlate closely when the changes that have occurred are caused by heat. Such effects were more common among samples examined than were quality defects due to abnormal fermentations, low or high salt concentrations, or similar faults.

Hunter *a* and R_d values correlate well with color and flavor scores. Thus color quality may be determined by the Hunter *a* and R_d values which correspond to hue and brightness in the case of sauerkraut color. Statistical analysis of the results indicate that the *a* value may carry about four times the weight of the R_d value in determining color score.

Sauerkraut packed in tin retained its color and ascorbic acid content better than kraut packed in glass, during processing and storage. Kraut deteriorated rapidly at high storage temperature as shown by change in both hue and brightness (*a* and R_d values), and by destruction of ascorbic acid.

Canned sauerkraut stacked in cases in the warehouse immediately after water cooling cools slowly and after five days shows a marked deterioration in hue and brightness of color.

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Utilization of Instrumentation in the Wet Milling Industry[a]

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Important advances have been made in the processing of corn since the end of World War II by the wet milling industry. Instrumentation has played an important part in helping to make these improvements possible. Corn sugar refineries serve as good examples of how instrumentation can be applied to existing batch processes and how satisfactory operation of a continuous process is made possible with automatic controls.

A drying channel for starch is used to illustrate the importance of coordinating through automatic controls the several successive steps in a process. Some examples of unusual applications point out possibilities for expanding the field of usefulness for instrumentation. Of particular importance is a basic new approach to placing information before an operator which will show him the significance of instrument readings with respect to the operation of the process.

The corn wet milling industry was developed in an era when processes usually were made up of a series of batch operations, and no means were available for carefully coordinating these steps into a unified process. Starch was the large volume product which was separated from other parts of the corn and then washed to remove soluble impurities before being dried as the saleable product. Criteria for judging the effectiveness of the separation steps and the drying operation were limited essentially to the human senses, which were keenly developed by those highly skilled in the art to make possible profitable operations. Giant plants grew out of the need for more and more of the products which were being supplied by this basic industry, and with them came additional products made both from the basic starch component and from the other parts of the corn which until then had been considered waste materials.

The large volume-producing plants in which large amounts of expensive equipment were installed could not be converted profitably to make use of newer processing techniques as long as operating personnel skilled in the art of making these products was available in sufficient supply. Hence, prior to World War II, processing equipment and methods for operating it had not changed significantly in this industry since its development on a large scale basis near the start of the century. The impact of the war in shifting the labor market, coupled with the broad technological advances made as a consequence of the war, led to a re-examination of the possibilities for making significant improvements in processing operations and for making more effective use of operating personnel.

COMPARISON OF BATCH AND CONTINUOUS PROCESSES

A typical example of a manually-regulated batch operation is the conversion of starch to dextrose. A starch slurry of constant density is acidified with hydrochloric acid by the addition of a fixed volume of acid to a known volume of starch slurry. This material is discharged into a reactor, or converter, where steam is added to bring the mixture up to temperature. When the dextrose concentration has reached the desired level, the contents of the converter are discharged to a succeeding tank into which is added a quantity of sodium carbonate sufficient to neutralize the free acidity remaining in the converted starch liquor. Several such converters and associated equipment may be required to satisfy the production needs at a particular plant. The flow sheet for this portion of the process is shown in Figure 1. The details of the operation of this process have been described previously *(1)*.

Evaluation of the possibilities for replacing the numerous manual operations with a coordinated automatic control system in a plant which was being designed shortly following the end of the war developed interesting opportunities for savings in capital expenditure and processing area requirements. At the same time, there were evidences that the product uniformity might be considerably improved. Experience in operating with this control system for a period of over two years has shown the benefits to be at least as favorable as had been anticipated. The revised process flow sheet is shown in Figure 2.

The above example illustrates the application of coordinated instrumentation and automatic controls to a batch process. Frequently the same operation can be carried out continuously, but only if an adequate automatic control system is included as an integral part. In the design of the refinery for the Corpus Christi plant of Corn Products Refining Company, a continuous process for converting starch to dextrose was selected and this serves as an illustration of the application of automatic controls for a similar processing function but in a differently designed process.

The flow sheet for this portion of the refinery is shown in Figure 3, and it may be noted that the starch supply is both acidified and diluted continuously to satisfy measurements made

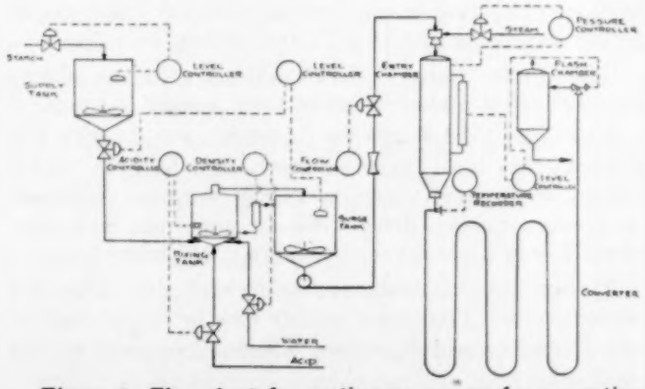

Figure 3. Flow sheet for continuous process for converting starch to dextrose.

[a] Presented at the Eleventh Annual Meeting of the IFT, New York, N. Y., June 20, 1951.

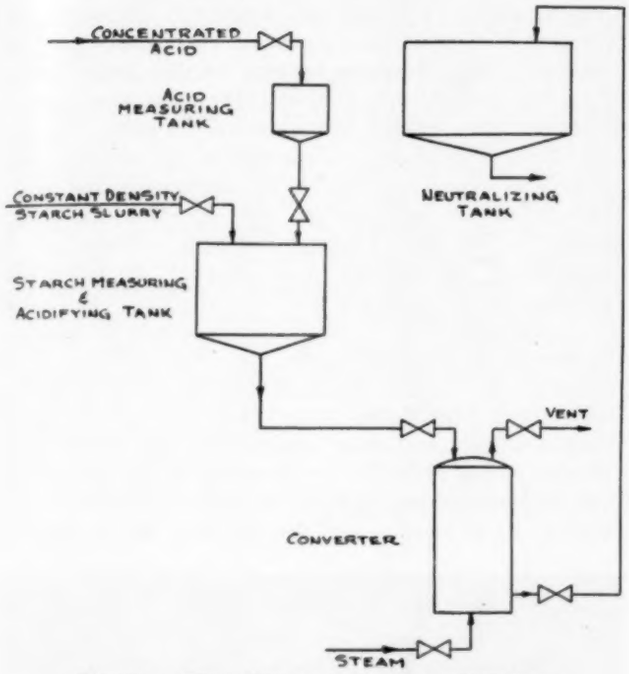

Figure 1. Flow diagram for a batch converter.

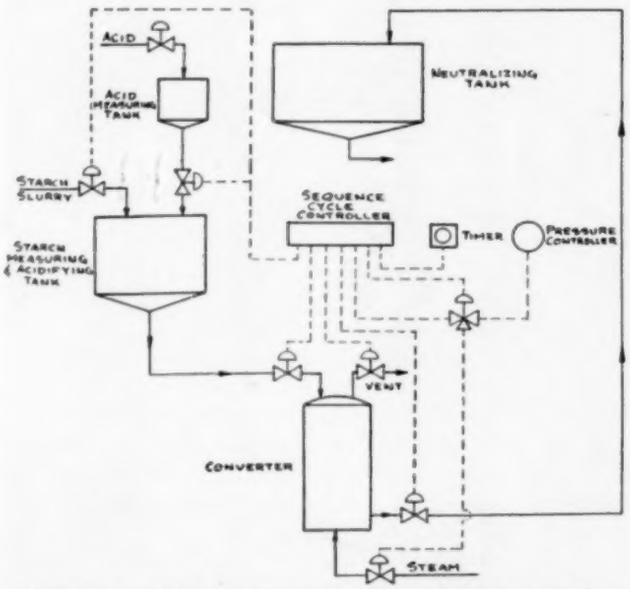

Figure 2. Schematic layout for automatic cycle control.

with concentration measuring instruments. While holding time could be controlled accurately with a time cycle controller in the batch operation, the continuous process requires the use of accurate flow control through a converter of fixed length to achieve the uniformity of holding time required. A pressure controller continuously throttles the steam input to the entry chamber to maintain the desired converting temperature which is continuously recorded. The converter tubing is kept full by regulating a discharge valve from measurement of liquor level in the entry chamber. This coordinated control system makes possible the effective use of continuous conversion with lower initial and operating costs, higher yields, and greater product uniformity than is possible with the automatically operated batch system.

ANALYSIS OF STARCH DRYING CHANNEL

The importance of fully coordinating operations within a process has been stressed in describing the application of controls to two different starch to dextrose converter station designs. A typical starch drying channel may be used to further illustrate the importance of coordinating the several steps of a process.

This is basically a simple operation wherein a starch slurry must be dewatered to produce a dry product having about 12% moisture. Good economics dictate the use of mechanical dewatering devices to the greatest possible extent to avoid excessive fuel costs in drying with heat. In this case, a continuous string type filter is used to reduce the water content of the starch slurry from about 20° Baumé to a filter cake containing about 45% moisture. The remainder of the water is then removed in a continuous belt type dryer with heat obtained from steam in coils around which drying air passes. The entire process is illustrated in detail in Figure 4. This illustrates the

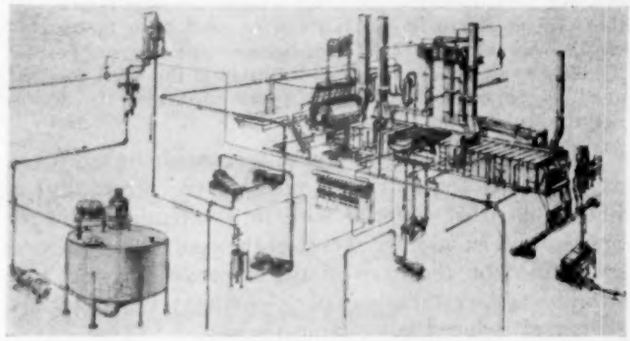

Figure 4. Detailed illustration of starch drying channel.

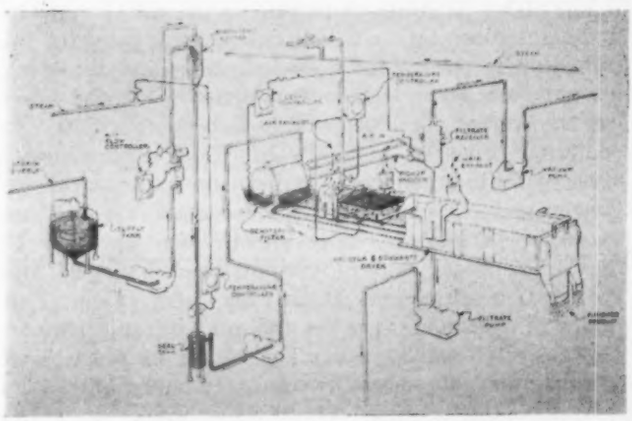

Figure 5. Simplified illustration of starch drying channel.

general relation of the several parts of the process and in particular shows details of the filter and dryer combination with the drying being accomplished in several zones within the dryer. A simplified, illustrative flow sheet of the process is shown in Figure 5.

If uniform moisture content is to be realized in the finished product at a production rate which effectively utilizes the capacity of the entire system, it is important that all phases of the dewatering operation be carefully examined. The heat balance within the dryer must be adjusted at all times to create an evaporating rate which will cause moisture to be removed from the filter cake to the desired final moisture content. The application of automatic controls to this type of dryer in the past customarily has involved the use of temperature controllers to maintain a constant air temperature above the bed of starch through adjustment of steam input to the coils. This assumes that the drying load will remain constant or that the operator will be able to detect changes in time to make adjustments, and thus a uniform product moisture will be obtained. Experience has shown that the drying load is not constant but that changes in drying load can be reflected by the measurement of the tem-

perature of the air after it has passed through the bed of starch if proper consideration is given to the selection of the measuring and controlling devices. In this case, each of the six zones is separately controlled by regulating heat input to the coils on the basis of satisfying a predetermined temperature beneath the moving starch bed in each of the sections.

In order to achieve the desired operation from the filter, means must be provided for regulating filtration rate as a function of the starch supply density and the required production rate. The starch supply must be maintained at an optimum temperature to effect maximum filtering effectiveness, and means must be provided for setting the rate at which the entire drying system operates. An automatic flow controller continuously regulates the discharge rate from the supply tank and a direct contact type heater is used for heating the starch slurry. Steam flow to the heater is regulated by a temperature controller which measures the temperature of the heated material in the heater downleg. By operating the filter without an overflowing bed, the level of slurry in the bed can be used as a measure of whether the filtration rate is in balance with the supply rate. The pickup vacuum is regulated to maintain this level constant, and the operation of the filter is controlled with the desired degree of uniformity.

The coordinated operation of this simple unit process, as described above, makes possible the production of uniformly dried material with little attention from the operator. The additional cost of the control instruments is justified on the basis of the improved product uniformity and certain operating savings related to fuel costs and reduced labor requirements.

GRAPHIC PANELS

The above illustrations pertain to the use of conventional instrumentation which customarily provides information to the operator on indicating and recording instruments. Experience over a period of several years has shown that operators who have been accustomed to operating processes manually based on measurements made with thermometers, hydrometer bulbs, pressure gauges and the human senses frequently require an extended period of readjustment when assigned to operate a process almost entirely from indicated and recorded measurements at an instrument panel. This period of transition is greater and more difficult than if a new operator wholly unfamiliar with past practices is assigned to an automatically controlled operation.

Within the last two years considerable work has been done on the development of so-called "graphic panels" on which the instruments are developed as a basic part of the process flow plan. Generally, a measurement is shown on a standard pressure gauge or a small size recording instrument incorporated into a unit with a manual-automatic station and required control functions. While the operator can grasp the relation of this particular measurement to the process, frequently the valve, or other controlled element, is not located near that part of the process, and he must mentally connect the correct controlled element to the measurement. If he has been used to reading thermometers, hydrometer bulbs, and gauge glasses, for example, the positions of pointers on scales and pens on charts do not create a prompt understanding of the significance of the measurement. As the complexity and number of operations increase, these factors increase in importance.

In an attempt to carry the graphic panel design still farther toward the point of maximum utility by operating personnel, a design was conceived for automatic operation of a series of triple effect evaporators used to concentrate light dextrose liquors. In this design every effort was made to fully submerge the measuring instruments into the process and illustrate all measurements and valves graphically in a manner which imitates with symbols as closely as possible the measuring and position indications with which the operator has been familiar in the past. Through a unique combination of components, the change from manual to automatic operation at the panel creates no confusion in the mind of the operator since the same manipulations to regulate the process are made in each case. This graphic panel design as applied to a triple effect evaporator is shown in Figure 6. Use of this system over a period of several months on this and other applications has shown that the transitional period is greatly reduced and that better operating results are obtained because of the more complete understanding which the operator has of signifi-

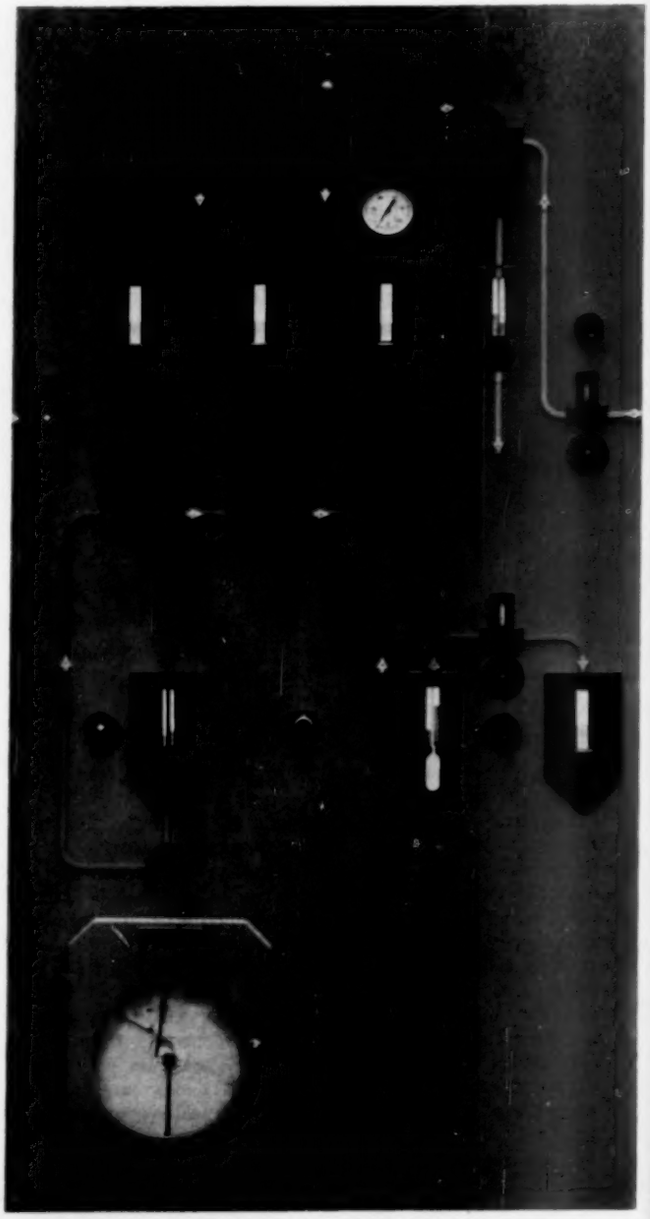

Figure 6. Graphic panel for a triple effect evaporator.

cance of measurements and the manner in which his efforts can be best used to coordinate the control of the process.

CONCLUSION

The illustrations which have been used refer to only a few of the many parts of the corn wet milling industry in which instrumentation has been successfully applied. Numerous separations in the wet process are being regulated automatically with beneficial results as are feed and gluten meal drying installations, numerous starch modification processes, and certain chemical operations. In some instances, specialized devices have been designed to meet specific requirements as, for example, an instrument for continuously measuring and recording the concentration of sulphur dioxide in process waters, which is now in regular use. In many cases, entire processes have been basically redesigned to effectively utilize the maximum benefits possible with instrumentation. The corn wet milling industry has awakened to the possibilities for improving operations with greater returns and improvement in working conditions through effective use of automatic controls, and the next decade should see broad acceptance of this philosophy throughout the industry.

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Frozen Cooked Rice. II. Brown Rice

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(Manuscript received August 30, 1951)

Brown Pearl and brown Patna samples of rice were cooked with a measured volume of water for 15 minutes, steamed 50 minutes, then air-cooled, packaged, and frozen at —10° F. (—23.5° C.). They were stored at 0° F. (—18° C.) for periods of 1 week, 2 months, 6 months, and 12 months. The rice was prepared for serving by steaming for 10 minutes. Judges found the rice scarcely distinguishable from freshly cooked rice in every respect even after one year of storage.

In a previous study *(1)* reported by this Laboratory, it was shown that frozen cooked polished rice was fully equal to freshly cooked rice even after eight months of storage at 10° F. (—12° C.). The present study was undertaken to determine how well-cooked brown rice would withstand frozen storage, and in general, whether the stored product would be as satisfactory in all respects as freshly prepared brown rice. If the indications were favorable, frozen brown rice might become attractive for large-scale development. Processing costs would be similar to, but possibly slightly higher than, those reported in the previous study on polished rice.

Brown rice is admirably suited for use in a variety of casserole dishes and in poultry dressing, or it can be served with butter and salt. It requires a longer cooking period than white rice, and for that reason is often neglected by busy homemakers, many of whom would prefer to use it because of its superior nutritional value and distinctive flavor. The saving of time with brown rice would probably be a decisive factor in establishing it as a retail item, provided it also retains its original quality during storage. Both types of rice, when cooked and frozen, could be made ready for table use in 10 minutes.

[a] Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, U. S. Department of Agriculture. Report of a study made under the Research and Marketing Act of 1946.

PROCEDURES

Preparation of the Rice

The success of any precooked frozen food depends basically on a high standard of excellence prior to freezing. To obtain the best cooking procedure possible, preliminary studies were made to determine optimum cooking times, amounts of water, and methods of preparation for both long- and short-grain rice. Since freezing may change the texture of a product, it was realized that the best procedure for rice to be frozen might be different from that recommended for freshly prepared rice. A difference was found and to compensate for it the quantity of water used in cooking was adjusted. This investigation was guided by an experienced rice tasting panel, who also scored quality factors in the stored frozen rice. The taste panel consisted of 12 laboratory staff members, all but one of whom had been members of the polished-rice tasting panel. Usually 9 or 10 of the members were present on a given day.

In the procedure selected (Table 1) the rice was weighed out and washed 4 times in rapid succession. After draining it was placed in a pan with the indicated amount of water and brought to a boil. It was stirred once, then boiled slowly (for 15 minutes for rice to be frozen, 20 minutes for freshly prepared rice) in a tightly covered pan. The partially-cooked rice was then transferred to a preheated gallon steamer with space provided around the edges for entrance of steam. Rice to be frozen was steamed for 50 minutes until slightly underdone, and that to be served immediately for 60 minutes. In neither case was it stirred during the steaming period, but the water in the steamers was kept boiling vigorously throughout.

The rice for the storage tests was cooled on trays in air, packaged in cellophane bags, and heat-sealed. Then it was frozen in rapidly circulating air at —10° F. (—23.5° C.) and stored at 0° F. (—18° C.). Just before the appraisal tests, the solidly frozen rice was placed in a preheated steamer and steamed over rapidly boiling water for 10 minutes. The same precautions against overcooking were used as in the previous study. Dry uncooked rice was stored for comparable periods at 0° F. and cooked, as required, for the taste tests.

Cooked rice was held for a maximum of 30 minutes between cooking and scoring. In order to minimize changes during the holding period, low heat was used, two circular layers of muslin were inserted between the water and food compartments to exclude steam, and the steamer cover was removed.

Scoring Procedure

The frozen rice was appraised and compared with freshly cooked rice at the end of 1 week, 2 months, 6 months, and 1 year. The factors scored were appearance, flavor, and texture. As in the preceding investigation on white rice, a scale from 1 to 7 for each characteristic was used, where 1 was the lowest score and 7 the highest. The judges could also check supplementary terms to indicate texture, such as too dry, too firm, too sticky, too soft, too fluffy, and slimy, or add other descriptive terms.

Appraisals of samples were made in 5 replications after each storage period. Both long- and short-grain samples were scored on the same day but not at the same time. A taster received either the long-grain or short-grain fresh and frozen samples, and upon completion of his judgment was presented with the other samples. The individual average scores of the tasters were analyzed by the variance and least-difference procedures.

TABLE 1

Cooking procedure for brown rice

Rice	Parts rice	Parts water	Boiling time	Steaming time	Reheating time prior to serving
			minutes	*minutes*	*minutes*
Freshly prepared					
Pearl	100	150	20	60	....
Patna	100	150	20	60	....
Frozen precooked					
Pearl	100	135	15	50	10
Patna	100	135	15	50	10

OBSERVATIONS AND RESULTS

The frozen cooked Pearl and Patna rice samples, prepared by the methods detailed here were of excellent quality, and remained so throughout the one-year testing period. Although the methods of preparation would require modifications if commercial production were involved, the principles should be the same to insure top quality.

Average scores for all samples are reported in Table 2. It will be noted that the differences between scores on any line in the table are small. Only 4 differences were statistically significant at the 5% level, of which 2 favored the frozen cooked rice and 2 the freshly prepared rice. It can be concluded, therefore, that frozen cooked stored brown rice compared favorably with freshly cooked rice even after 12 months of storage at 0° F. (—18° C.).

Small differences in quality scores for any one sample of rice between storage periods are not necessarily indicative of changes in the sample. These apparent discrepancies result from the inability of judges to duplicate their scorings after a lapse of time, as was brought out in the previous paper *(1)*. The purpose of this study was to compare frozen cooked rice with freshly prepared samples at the end of each period rather than to compare the frozen rice with itself from one storage period to the next. If direct comparison of storage periods were desired, a different experimental plan would be necessary.

TABLE 2

Judges' scores for stored rice

Rice	Quality factor	Storage period	Average scores for prepared samples of [b]		Least significant difference, P = 0.05 [c]
			Dry rice stored at 0° F.	Frozen cooked rice stored at 0° F.	
Pearl	Appearance	1 week	5.2	5.1	....
		2 months	4.4	4.6	....
		6 months	4.5	5.0	0.5
		1 year	4.6	5.0	....
Pearl	Flavor	1 week	6.6	6.5	....
		2 months	6.0	6.0	....
		6 months	6.0	5.3	....
		1 year	5.9	5.5	....
Pearl	Texture	1 week	5.4	5.4	....
		2 months	4.9	4.6	....
		6 months	5.0	4.9	....
		1 year	5.4	5.0	0.3
Patna	Appearance	1 week	6.1	6.0	....
		2 months	5.2	5.5	....
		6 months	5.1	5.6	0.4
		1 year	5.5	5.5	....
Patna	Flavor	1 week	6.6	6.6	....
		2 months	6.2	6.1	....
		6 months	6.0	5.5	....
		1 year	5.9	5.6	0.3
Patna	Texture	1 week	5.9	5.8	....
		2 months	5.5	5.2	....
		6 months	5.4	5.5	....
		1 year	5.2	5.2	....

[b] Highest scores indicate best quality.

[c] A dash indicates that the differences found were not significant at the 5% level. No differences found between comparable freshly cooked and stored frozen rices were significant at the 1% level.

The descriptive terms checked by the judges are summarized in Table 3. Since any one sample showed so little change during storage, totals for the 4 periods are given. Terms which received check marks numbering less than 10% of the total judgments for each of the four samples in the group are omitted. The difficulty of cooking brown rice to make it acceptable in every respect to all members of the taste panel is reflected in the large number of check marks for "too firm" and "too soft." In addition, the Pearl rice was rated too moist in many instances. The cooking procedures described earlier in this report and summarized in Table 1 are therefore compromises selected to give the best possible balance of properties to the cooked rice.

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TABLE 3

Judgments indicating texture of fresh cooked and frozen stored rice [d]

Rice	Storage conditions	Percent of total					
		Too dry	Too firm	Too moist	Too sticky	Too soft	Slimy
Pearl	Dry rice stored at 0° F.	2	26	38	10	20	9
Pearl	Frozen cooked rice stored at 0° F.	3	43	42	5	34	11
Patna	Dry rice stored at 0° F.	13	26	8	7	28	2
Patna	Frozen cooked rice stored at 0° F.	4	33	7	5	43	2

[d] Results for all storage periods combined. No trends with storage period were apparent. The total number of judgments for each type of rice was 193.

The Effect of Cleaning on the Flavor and Interior Quality of Shell Eggs[a]

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(Manuscript received July 10, 1951)

Various criteria have been used to determine the possible effects of washing eggs on their quality after 7 and 65 days of storage. The methods of organoleptic testing for such flavor effects in eggs is discussed in detail.

It is generally conceded that one of the major problems in poultry and egg marketing is the proper handling of dirty eggs. In certain seasons as many as 17% of the total eggs marketed in the North Central States area are stained and dirty *(1)*. It is commonly accepted that the most satisfactory solution to this problem is probably to be found in improved flock management practices; however, as long as higher prices are received for clean eggs (whether previously dirty or not) the cleaning of the dirty ones appears inevitable The results to be reported here are a portion of a comprehensive study to determine the effect of cleaning on the quality of shell eggs. They were concerned with the more subtle effects (as compared to actual spoilage) of washing on the flavor and interior quality of shell eggs.

Eggs readily absorb flavors and odors from feedstuffs and odoriferous materials during storage. Vondell *(24)* reported that "fishy" eggs are characteristic of individual hens and may be eliminated by proper flock selection. McCammon, Pittman, and Wilhelm *(13)* observed that in addition to a deeper yolk color, yellow corn and green wheat feeding result in less desirable odors and flavors in eggs. Holding the eggs for rather short periods removed a portion of the objectionable odors and flavors. It was concluded that the average consumer would probably not object to the lowered organoleptic quality. Robertson and Wilhelm *(20)*, and Vondell and Putnam *(25)* concluded that, when fed, odoriferous materials (salmon fish meal, cabbage, kitchen garbage, and sardine oil) had little effect on the odor and flavor of eggs unless consumed in excessive quantities.

Jenkins *(11)*, Pennington *(16)*, Moran *(15)*, Rudolph *(21)* and others have observed changes in the organoleptic qualities of shell eggs when held in cold storage. The changes observed by them were probably due to the effects of the increased alkalinity as well as the absorption of odors or flavors from the surroundings *(22)*. Slocum, Lee, Swenson, James, and Steinbarger *(23)* found little correlation between the candling grade and the flavor of stored oil treated eggs. The colorless, tasteless, and odorless mineral oils commonly used for preserving eggs had no adverse effect on the flavor.

In a series of carefully conducted experiments, Sharp, Stewart, and Huttar *(22)* examined the effect of packaging materials on the flavor of storage eggs. Flavor absorption was found to be dependent upon the type of packaging material and the humidity of the atmosphere. They also noted that off-flavors were generally more pronounced in eggs having a higher pH. Gaebe *(8)* studied the use of "Avenized" (oat flour treated) strawboard flats and fillers and concluded there was no indication of any difference of flavor between the eggs of the two treatments. A slight preference for the odor of the eggs stored in the "Avenized" materials was recorded. Gross, Hall, and Smock *(9)* reported that dipping in mineral oil reduced the storage odor in eggs; however, air purification with activated carbon was even more effective.

While no work concerning the absorption of odors and flavors due to washing eggs was found in the literature, it seems quite likely that certain compounds and methods might give rise to changes in flavor.

Only occasionally have the investigators studying egg washing concerned themselves with the effects on the interior quality. Bryant and Sharp *(4)* reported that washed eggs do not lose weight more rapidly than unwashed eggs. Their results have been confirmed by Rhodes and Godfrey *(19)* who concluded that washing in synthetic detergents and 2% NaOH at temperatures up to 155° F. (67° C.) did not remove enough of the cuticle to allow excessive evaporation. These latter results are consistent with the predictions of Marshall and Cruickshank *(14)*. Funk *(7)* reported that eggs cleaned with NaOH and stored had satisfactory cooking qualities after 8-10 months. Dawson, Davidson, and Sheppard *(6)* concluded that the candling grade of washed and oiled eggs was slightly lower than that of clean, unwashed eggs but found no differences on the basis of interior quality measurements. While the present work was in progress, Pino *(18)* reported that eggs washed by repeated dipping (for three second periods) in a detergent solution at 140° F. (60° C.) suffered no significant loss in quality as measured by weight loss, candling grade, albumen index, and yolk index. MacDonald *(12)* soaked eggs in detergent solutions for 30 minutes at 100-110° F. (39-43° C.) and reported that the treatment did not reduce the quality of the egg albumen as measured by its ability to produce a satisfactory angel cake. There appears to be no evidence to support the view held by many egg handlers that the high temperatures used in certain washing

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procedures have a deleterious effect on albumen or yolk quality.

In the past several years the importance of the techniques involved in subjective evaluation of food products for odors and flavors has been generally recognized. The psychological and physiological principles underlying this method of analysis are gradually being established. Boggs and Hansen *(3)*, Harrison and Elder *(10)* and Peryam and Swartz *(17)* and others have reviewed and discussed the techniques now available to the research worker. A discussion of these procedures is outside the scope of the paper.

EXPERIMENTAL

All eggs used in this study were obtained from the Iowa State College Poultry Farm. Clean eggs were selected each evening from that day's production and held overnight at 55° F. (14° C.) prior to washing. Only clean eggs were selected in order to remove the possibility of soil taints.

Eggs were washed (soaked) in Compound "A" [c] (0.5% in water), "B" [d] (200 p.p.m. in water), and "c" [e] (0.5% in water) at 110° F. (43° C.). Fresh solutions were prepared daily. Ten and 30 minute soaking periods were used. The eggs were dried rapidly in air; they were then placed in new one-dozen cartons. Six treated and six control (unwashed) eggs were placed in each carton and immediately placed in storage at 33° F. (1° C.) and 86% relative humidity.[f] Constant air circulation was provided.

Interior quality measurements used in this study were the Haugh unit and yolk index. Haugh units were determined in the usual manner, two measurements of albumen height being averaged before consulting the nomogram *(2)*. Yolk index is the ratio of the height to the width, two measurements (made with the yolk in place) being made for each value. The pH was measured with a Leeds and Northrup glass electrode pH assembly after the albumen and yolk were thoroughly mixed. All measurements were carried out with the eggs at room temperature (70-80° F.).

The methods used for the subjective evaluation of the odor and flavor of the eggs were a combination of the "triangle" and the "paired difference" tests. The egg was prepared for evaluation by scrambling the thoroughly mixed albumen and yolk of six eggs in a double boiler over boiling water. Approximately 10 minutes was required for the egg to be cooked to an end-point determined by visual observation. Every possible precaution was taken to eliminate any differences in the appearance and temperature of the egg when submitted to the judges.

A panel of six young women were used in this study. They were not allowed to smoke or eat for two hours before the tests. All tests were carried out at 10:00 A. M. during a rest period from their regular duties. The panel was selected and trained on the basis of the individual's acuity for the odor and flavor of the test materials. The scrambled eggs were served hot in prewarmed white sauce dishes. Each dish was code marked on the underside so that it could not be seen until the tests were completed. The odd sample was the treated sample in all cases.

The layout for each judge is shown in Figure 1. The following instructions were printed on the forms used for recording the results:

> "The first single dish is a warm-up sample. Taste and smell it to get the "feel" of the product. It may or may not be like any of the other samples. Rinse your mouth with a small quantity of water. Each of the remaining samples contains three dishes of scrambled egg. Two of these dishes are alike and one is different. *Which is the odd (single) dish?* Rinse your mouth after tasting and smelling each sample."

Each day two samples were used for two "triangle" tests, one of these being a 7 day and the other a 65 day storage sample; the order of presentation was random. After the "triangle" test odd dish numbers were recorded, the judges were asked to select the storage sample. The average time required by the judges to make and record their observations was less than five minutes.

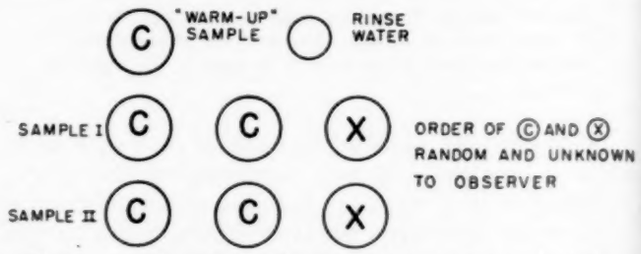

Figure 1. Layout of the triangle test for each judge. Adapted from Peryam and Swartz (17).

RESULTS AND DISCUSSION

In these experiments there were a total of twelve separate treatments so designed to approximate a so-called split-plot factorial design *(5)*. Each of the 4 replicate samples contained 6 treated and 6 control eggs (held in the same manner but not subjected to the washing). The eggs used for the measurement of interior quality were also used for the flavor and odor tests. This made it possible to isolate several variables which might conceivably have had an influence on the flavor or odor.

The results of the interior quality observations are shown in Table 1. It is readily apparent, and this was verified by statistical analysis, that no significant differences in Haugh units, yolk indices, or pH exist between the treated and control eggs in any of the treatments used. These findings are in agreement with those previously reported by other workers. Of primary importance to this study was the fact that these results permitted the conclusion that any flavor differences found could not be attributed to differences in the interior quality and more specifically not to differences in the pH. Sharp, Stewart, and Huttar *(22)* reported the relatively easier detection of off-flavors in eggs with a high pH, hence, it was considered significant that no pH differences existed between the treated and control eggs.

Several experiments were carried out during the preliminary training period for the panel in order to determine the concentration of the washing agents that could be detected. A panel threshold value for each material was considered, by definition, to be that concentration of the washing agent that could be detected 50% of the time, chance selection being eliminated. The triangle test procedure was used with different quantities of the washing agents added to the egg just prior to scrambling. The objectives of these experiments were two fold; first, to train the panel in the technique and to acquaint them with the flavors and odors to be encountered, and second; to obtain an estimate of the

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[c] "A" is primarily a neutral sulfated monoglyceride.

[d] "B" is primarily a mixture of high molecular weight alkyldimethyl benzyl ammonium chlorides.

[e] "C" is primarily a mixture of tetrasodium-pyrophosphate; sodium carbonate, trisodium phosphate, polyethylene glycol ester of oleic acid, and trimethyloctadecenyl and trimethyloctadienyl ammonium chlorides.

[f] Humidity was maintained at 86 ± 1.5% by an American Instrument Co., Electric Hygrometer installation.

TABLE 1

Effect of cleaning treatments on the interior quality of shell eggs used for flavor tests.

Treatment			Haugh unit		Yolk index		pH [g]	
Type	Soak time	Storage time	Treated	Control	Treated	Control	Treated	Control
	minutes	*days*						
A	10	7	83.1	87.2	0.508	0.516	7.54	7.53
A	30	7	80.8	85.9	0.504	0.526	7.43	7.42
A	10	65	75.3	70.1	0.503	0.513	7.68	7.60
A	30	65	68.2	73.8	0.514	0.513	7.61	7.58
B	10	7	81.2	81.6	0.499	0.530	7.48	7.47
B	30	7	83.6	80.8	0.502	0.523	7.47	7.48
B	10	65	74.5	71.7	0.513	0.510	7.53	7.52
B	30	65	74.2	74.8	0.518	0.505	7.63	7.54
C	10	7	80.7	80.1	0.522	0.518	7.64	7.63
C	30	7	82.7	77.9	0.517	0.514	7.48	7.37
C	10	65	69.0	69.6	0.508	0.528	7.47	7.38
C	30	65	71.1	70.6	0.492	0.504	7.57	7.53

[g] Determined on the mixed whole egg.

amount of these materials required to impart a taste to the scrambled egg. The results obtained indicate that "B" was detected at a concentration of 750 p.p.m.; "C" next, at about 1500 p.p.m.; and "A" at about 3000 p.p.m. It is important to note that these results have application only when the taste panel used for these experiments is considered, and entirely different results, both as to the order and the amounts of any one material detected, might be obtained with a different panel, or even with the same panel in a different state of training. The results are important to this study as they give a rough approximation of the quantity of the washing agents (or the aromatic volatile components contained in them) penetrating the egg shell in the washing and soaking experiments.

The "triangular" test results obtained on the scrambled egg prepared from the variously cleaned and stored shell eggs are shown in Table 2. The number of total and correct observations is the sum of those values obtained in four replications carried out at approximately one week intervals. The critical ratio is a statistic derived and calculated according to Peryam and Swartz *(7)*. The level of significance was determined by consulting a table of areas under the normal curve with the critical ratio figure as a positive sigma distance. When each treatment is considered individually it is apparent that in only two cases were the differences observed better than the 5% level of significance. The percent level of significance in the last column, as is customary, indicates the percentage of times these same results would have been obtained had the samples actually been identical.

TABLE 2

Triangular test results on scrambled eggs prepared from variously cleaned and stored shell eggs.

Treatment			Total observations	Correct observations	Critical ratio [h]	Level [i] of significance %
Type	Soak time	Storage time				
	minutes	*days*				
A	10	7	20	10	1.59	5.59
A	30	7	22	15	3.49	0.02
A	10	65	16	8	1.42	7.78
A	30	65	21	6	0	.....
B	10	7	16	8	1.42	7.78
B	30	7	21	10	1.39	8.23
B	10	65	20	7	0.16	43.64
B	30	65	22	13	2.57	0.51
C	10	7	20	10	1.59	5.59
C	30	7	21	10	1.39	8.23
C	10	65	20	10	1.59	5.59
C	30	65	15	5	0	.....
All A	....	....	79	39	3.04	0.12
All B	....	....	79	38	2.80	0.26
All C	....	....	76	35	2.37	0.89
All	10	....	111	53	3.23	0.6
All	30	....	122	59	3.55	0.2
All	....	7	120	63	4.47	0.01
All	....	65	113	49	2.29	1.10
Overall total			233	112	4.80	0.01

[h] Determined by the method described in reference *17*.
[i] From Table of Areas under Normal Curve.

The sensitivity of tests of this nature is greatly increased with an increased number of trials; this is quite apparent when the results obtained from all eggs treated with all washing agents are combined. A highly significant (better than 1%) difference exists between the treated and control eggs. Statistical analysis of the percent level of significance values might indicate the relative ease of detection of the different cleaning materials but could not be carried out on these data. The differences are so small that it is doubtful if they are significant, however.

In the comparison of the combined 7 and 65 day storage periods samples, it is concluded that the "soapy" flavors can be detected more readily in the fresh eggs than in the storage eggs. This might be at least partially explained by the assumption that 1, the natural organoleptic changes taking place in stored eggs tend to mask the off-flavors and odors and 2, that the longer storage period offered an opportunity for the diffusion and removal of the flavor introduced by the soaking procedure.

The overall level of significance (better than 0.01%) can leave little doubt that the panel used in these experiments was able to detect the presence of foreign flavors and odors in shell eggs washed in these washing compounds and under the conditions described.

Several experiments were carried out in which a water-soluble dye, thionin,[j] was added to the soaking

[j] Thionin, or Lauth's violet, is a strongly basic dye, C. I. 920, said to be specific for ovomucin. The concentration used was 0.25%.

solution. In no instance, when the soaking solution was maintained at exactly 110° F. (43° C.), was there any visible penetration of the dye through the pores. When the dye solution was colder than the eggs, or when the warm solution was allowed to cool while the egg was in it, very rapid penetration of the dye into the egg white was observed. A temperature differential as small as 5° F. (2.8° C.) resulted in dye penetration as far as the shell membranes. These observations are in accordance with present theories pertaining to microbial penetration of the egg. These results suggest that the flavors of shell eggs washed in odorous and flavorous washing agents are altered by those materials being deposited on the shells and the volatile constituents subsequently absorbed through the pores. No adequate explanation can be given for the observations that solution "B," while used at a concentration of only 200 p.p.m., and not detected by the panel in the threshold tests until a concentration of about 750 p.p.m. was reached, actually altered the flavor of scrambled eggs. Immediate rinsing in clean, warm water might be an effective method of preventing flavor or odor absorption.

The question "Which is the storage sample?" was answered correctly 76 times out of a total of 109 tests (70%). By statistical procedures similar to those used in the "triangle" test, a level of significance of better than 0.01% was estimated. This result is in agreement with, and substantially supports the present view that the flavor and odor of storage eggs is different than fresh eggs. No indication was obtained in these experiments of a preference for either sample.

SUMMARY AND CONCLUSIONS

Under the conditions of these experiments, washing eggs in aqueous solutions at 110° F. (43° C.), for periods of 10 and 30 minutes, and subsequent storage for 7 and 65 days had no adverse effect on the interior quality of shell eggs as measured by Haugh units of the albumen, yolk index, and pH.

Subjective evaluation of the flavor and odor of these eggs with a trained taste panel indicated that the flavors and/or odors were absorbed from the washing solutions under all conditions studied, but were less noticeable after the eggs were held in cold storage for approximately two months. Identification of storage eggs was accomplished easily by the panel with no previous training or experience with storage eggs.

The results of this study should indicate to the manufacturers of materials designed to be used as egg washing agents the importance of the organoleptic properties of their products.

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Rapid Method for Moisture in Fruits and Vegetables by Oxidation with Dichromate. I. Potatoes and Peas

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A rapid, simple method, designed for measurement of moisture in fresh or moist materials but which may also have limited applicability to dry materials, is based upon oxidation with potassium dichromate solution. All results are referred to this easily prepared, permanent primary standard, thus promising a high degree of inter-laboratory reproducibility. The dichromate equivalent of each material is determined in terms of the slow reference method of interest. Therefore an analysis, which takes 5 to 10 minutes, exclusive of grinding, or slurrying, and weighing of specimens, gives results in terms of that reference method. Usually 12 determinations can be made per hour. Data are presented on precision and accuracy for dehydrated and fresh materials.

Methods for moisture in foods have been discussed by Makower *(15, 16)* and by Mitchell and Smith *(17)*. Although the oven methods are most extensively used and are frequently the basis for large-scale procurement of foods for the armed forces, they are often too slow for the control of manufacturing processes whose products must meet moisture specifications or be rejected, sometimes in carload lots. Most of the rapid electrical methods are limited to the range of low moisture, involve costly equipment, and are generally less precise than the vacuum oven procedure. Hlynka, Martens, and Anderson *(11)* studied the performance of 10 commercial electrical moisture meters on one variety of wheat. Their data for a well-known make of instrument, intermediate in the group, showed mean and maximum deviations of 0.32 and 0.9% moisture, respectively, of the instrumental values from their vacuum oven calibration curve. Another instrument showed a constant difference of 0.75% moisture between their calibration curve and that of the manufacturer. Geise, Homeyer, and Tischer *(10)* measured moisture values of fresh corn and found mean and maximum differences of 1.0 and 3.0% moisture, respectively, between vacuum oven values and those using another type of electric meter. They also found mean and maximum deviations of 1.3 and 4.7% moisture, respectively, between vacuum oven values and those obtained with the Brown-Duvel method, a slower procedure involving distillation.

The rapid Karl Fischer method *(17)* is the most promising procedure in use at the present time for dehydrated materials. Makower *(15)* has discussed such factors as reagent instability, specificity, and completeness. Since no agreement between this method and the arbitrary 6-hour vacuum oven technique, for example, can be expected, the Fischer method must be standardized for each material in terms of the latter method if the standards already established in the food industry are not to be upset.

An entirely different approach to the problem of moisture determination in fruits and vegetables has been attempted by the writers. In this method nonaqueous organic matter is determined by oxidation with dichromate solutions and moisture is measured by difference. If a specimen, whose moisture content has been determined by a slow, painstaking reference method, can be rapidly and reproducibly oxidized by standard dichromate solution, then the moisture content of another specimen of the same sample may be quickly and accurately determined on the assumption that the sample is uniform in every respect but moisture content. If, further, a specimen of any random sample of the same species is oxidized and the moisture content calculated from the dichromate consumed, then the error in the value depends upon the difference between the dichromate factors of the random sample and of the sample of known moisture content.

This paper describes experiments in which this approach was tested, and deals with the development of a rapid, simple, reproducible technique employing inexpensive equipment for oxidizing potatoes, peas, and the carbohydrates glucose and sucrose, and the application of this technique in a method that is rapid enough for many control applications. It describes, furthermore, a study of the errors to be expected in applying the method to random samples, and a study of the causes of such errors. The writers intend to present results of studies on other commodities at a later date.

PRINCIPLE OF METHOD

Oxidation with potassium dichromate in hot sulfuric acid solution has been used for the determination of a variety of comparatively simple organic acids, esters, sugars, amines, etc. *(1, 2, 3, 7, 8, 9, 13, 18)*. These methods were based upon the determination of the CO_2 evolved, and since the process usually employed heating, for example 30 minutes at 165° C., the methods were unsuitable for rapid simple routine application. In contrast, a more rapid technique, in which the excess dichromate is determined by titration, has been used in cellulose chemistry *(3, 5, 6, 12, 14, 19)* and for fatty acids *(4)*.

The oxidative process for carbohydrates may be represented by the equation for the oxidation of cellulose:

$$C_6H_{10}O_5 + 4Cr_2O_7^{=} + 32H^{+} = 6CO_2 + 21\ H_2O + 8\ Cr^{+++}$$

This equation was found to hold acceptably for certain applications in cellulose chemistry *(3, 12, 14)*, the criterion being agreement with gravimetric results. Other applications have required evaluation of the departure from theory due to the small amount of CO formed *(20)*.

In the present application, the dichromate equivalent of each material of interest is determined and, therefore, the probably incomplete oxidation of foodstuffs is of minor consequence. It is true, however, that the more completely the various components

[a] Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, U. S. Department of Agriculture. Report of a study made under the Research and Marketing Act of 1946.

of a material are oxidized to some stable state, preferably but not necessarily CO_2, the greater will be the reproducibility of the method.

The present dichromate technique differs from previous ones in that the external heating operation was eliminated, and in its stead the heat of dilution of concentrated sulfuric acid is utilized to secure instantaneous, reproducible heating. The ground or slurried specimen is suspended in the standard dichromate solution before addition of the acid that starts the reaction. The excess dichromate is determined electrometrically. Details are given under Analytical Procedure.

From D, the milliliters of dichromate consumed per gram of specimen, the moisture content is calculated as follows: Moisture, percent $= 100\ (1 - F \times D)$; wherein F is the "dichromate factor" in grams of dry material per ml. of dichromate.

The accuracy of the method is a function of F and D. Variations in D involve the reproducibility of the oxidimetric procedure as well as the usual analytical manipulations. Error in percent moisture due to error in D equals $(100 - \%$ moisture$)/100(\%$ error in $D)$.

The value for F is usually an average that has been obtained from samples representing the batch, crop, strain, or species involved. It is determined by solving the equation for moisture for F and measuring moisture content by a reference method, in whose terms the moisture values calculated from this F will then be expressed. One set of determinations of F may suffice for plants processing a certain local product over a period requiring many moisture determinations.

It is apparent that variations in F will be the greater, the larger the category which F must represent, inasmuch as F can be expected to vary with organic and inorganic composition. The effect of ash is obvious. The effect of the difficultly oxidizable aliphatic acids, such as acetic, or of fats, may be appreciable. Even carbohydrates, although probably completely oxidizable, may cause variations in F because of their different oxidimetric equivalent weights, of which the following are typical: glucose, 7.51; starch, 6.75; and sucrose, 7.13 g. per equivalent.

Error in percent moisture due to error in F equals $(100 - \%$ moisture$)/100(\%$ error in $F)$, where by error in F is meant the difference between the individual F for a given sample and the mean F used to calculate moisture content.

Both relationships for the error in the percent of moisture show that the error decreases with rising moisture content and that the method has its optimum application in the analysis of fresh or moist materials.

ANALYTICAL PROCEDURE

Fresh or moist materials may usually be ground in an intermediate-size Wiley mill, having a 20-mesh screen, and then mixed with a spatula. Such mixing may not suffice for certain materials of intermediate moisture content, which may be mechanically blended with a known proportion of added water (not alcohol which reduces dichromate). Dry materials are preferably ground to 20-mesh size.

The size of the test specimen is 0.25 ± 0.02 g., dry basis, which leaves ¼ of the reagent in excess. Specimens 0.05 g. overweight gave a moisture content 0.55% lower, and specimens 0.05 g. underweight, 0.14% higher than the moisture content found using 0.25 g. of dehydrated potatoes (8% moisture), as an example. Thus it is preferable to use underweight rather than overweight specimens if time must be saved by exceeding these weight tolerances, but in any case the weight must be known to the accuracy compatible with that of the final result.

In a 400-ml. beaker 25.00 ml. of 1.835 N. standard potassium dichromate solution is added to the specimen. (This solution contains 90.00 g. per liter at 20° C. of reagent grade $K_2Cr_2O_7$ crystals, dried overnight at 100-140° C. This serves as a permanent primary standard. Recrystallization is usually unnecessary but the solution should be filtered.) Then 10 ml. of concentrated sulfuric acid, reagent grade, density 1.84, is slowly added (10 to 15 seconds) to the well-stirred mixture, covered by a watch glass. Thorough stirring was found to be most satisfactorily accomplished by a magnetically rotated glass-enclosed iron nail, 3/16-in. x 1¼-in., using a commercially available magnetic rotator. Stirring by hand was found to allow local reduction of the concentrated acid by the specimen, and resulted in 1% less dichromate being consumed by the specimen.

The heat of dilution of the acid raises the temperature to approximately 87° C. and when most of the oxidation is over (usually after 30 seconds, characterized by the moderation of foaming) 65 ml. more of the acid is added rapidly, which further increases the temperature to 115° C. After 10 minutes the solution is diluted with roughly 100 ml. of water and then may be titrated preferably hot or warm, since the end point response increases with temperature.

In an alternate procedure which saves time and sulfuric acid, 30 ml. of concentrated sulfuric acid is finally added, instead of 65. This gives a higher final temperature, 123° C., allowing the 10-minute interval to be shortened to 4 minutes, followed by dilution with 150 ml. of water, instead of 100. The dichromate value for potatoes is not affected hereby; that of peas is approximately 1.5% lower. Precision is not affected for either material. If results are needed within a few minutes after sampling, the 4-minute interval may be further shortened to 1 minute with the result that the dichromate factors are 1 to 2% lower under these conditions. Such a change does not affect accuracy as long as the same procedure is used for analysis and for determination of the dichromate factor. This demonstrates the flexibility of the procedure, and other changes, to suit individual situations, are doubtless possible. Reproducibility is not affected unless the time intervals are still further reduced, or unless the quantities are so changed that small variations in operation become critical.

The excess dichromate is titrated electrometrically with ferrous ammonium sulfate solution containing 195 g. of $Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$ and 10 ml. concentrated H_2SO_4 per liter. Atmospheric oxygen slowly changes the titer of this solution, but this does not matter, inasmuch as its concentration does not enter into the calculations. At the beginning and end of a series of determinations a reference titration is made. This is done by adding 5.00 ml. more of the same dichromate solution to a solution which has just been titrated, and retitrating to the same end point.

Although commercial titrimeters using two metal electrodes, or pH meters using Pt-calomel electrodes, and designed by the manufacturers for oxidation-reduction systems, are adequate, a device made from inexpensive parts is often preferable from the standpoints of cost and simplicity, and because the extent of deflection may be used to indicate the number of drops past the end point, if necessary. The circuit diagram is shown in Figure 1. At the start of the titration P is adjusted so that G reads zero. One drop of titrant at the end point gives a permanent deflection which cannot be confused with previous slow drift or with momentary fluctuations caused by inadequate stirring during titration.

Blanks should also be determined for the sulfuric acid by simulating the oxidation process with 5.00 ml. of dichromate solution plus 20 ml. water, then adding concentrated acid and finally diluting as before. Such blanks usually amounted to 0.01 ml. of 1.835 N. dichromate for 75 ml. concentrated acid from a carboy, compared to 0.03 ml. for acid from 9 pound bottles of commerce.

The dichromate used by the specimen is calculated as follows: Milliliters of 1.835 N. dichromate used by specimen $= 25.00 - 5.00 \times (V_d/V_r)$, where V_d and V_r are the volumes of ferrous ammonium sulfate required in the determination and reference titrations, respectively. The D in the equations above is the milliliters of dichromate per gram of specimen.

Knowing D and F, the moisture content of the specimen is calculated. The mean dichromate factors, F, 0.01338 for potatoes and 0.01373 for peas (Table 2 and 5) may be used for these vegetables. If feasible, the factor should be determined for the particular variety being tested.

PRECISION

Precision is of importance even on a relative basis, for it determines the agreement which may be expected between two analysts testing the same material at dif-

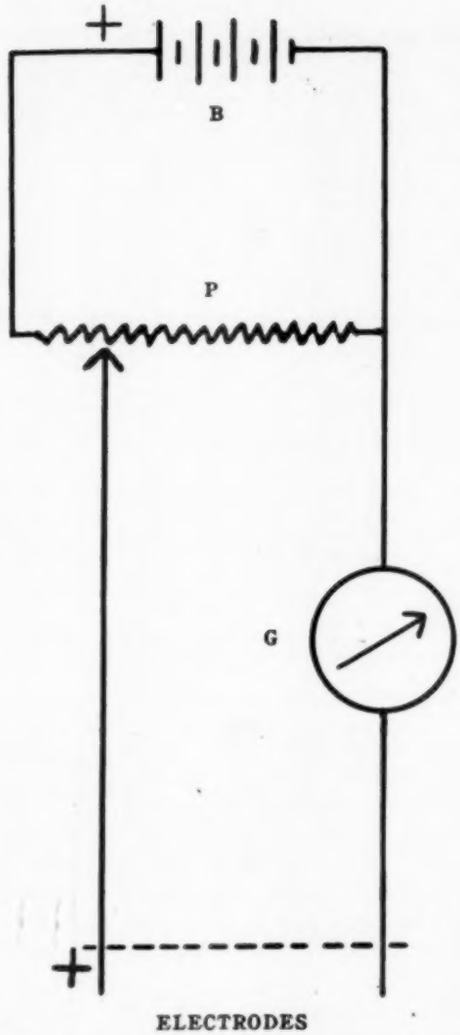

Figure 1. Simple electrometric circuit for the dichromate titration. B, 6 volt battery of dry cells. P, radio potentiometer of 500 to 5000 ohms; G, crude microamemeter, 1 to 2 scale divisions per microamp. The electrodes may be bare wires or of the usual commercial types, using platinum for the positive and either nichrome, tungsten, or a calomel electrode for the negative electrode.

ferent times and places, and with different equipment. This is often a decisive factor in specification work.

Replicate specimens of dehydrated potatoes and peas were oxidized by the technique described under Analytical Procedure. The results, given in Table 1, show that the dispersion of the oxidation value, *D*, for potatoes and peas, was 0.10 and 0.13%, respectively, standard deviations from the mean, corresponding to moisture errors of 0.09 and 0.12%, calculated by using the moisture values given in footnote [b], Table 1. These errors refer to the dried materials, ground to 20-mesh size. When slurries were prepared from ⅛-inch cubes of dehydrated potatoes or from fresh frozen peas and the replicate specimens oxidized as before, the dispersons in the *D* values were larger, 0.45% and 0.31%, respectively, due apparently to non-uniformity of the slurries.

The standard deviations for the dehydrated materials appear to be near what might be termed the ultimate

TABLE 1
Precision of the dichromate oxidation procedure for various materials

Materials	Number of replicates	Range of specimen weight [d]	D = Dichromate [e] volume per g. of specimen [d]	Standard deviations [f] from mean	Weight (dry) of material per oxidation equivalent
		g.	*ml.*	%	*g.*
Dehydrated potatoes [b]	10	0.2493 — 0.2639	69.23 ± 0.05	0.10	7.30
Dehydrated peas [b]	10	0.2491 — 0.2605	67.22 ± 0.09	0.13	7.40
Standard glucose [c]	12	0.2350 — 0.2472	72.13 ± 0.07	0.12	7.553 [g]
Standard sucrose [c]	10	0.2388 — 0.2474	75.83 ± 0.05	0.09	7.185 [g]

[b] Dehydrated potatoes and peas were ground to 20-mesh and contained, respectively, 7.32 and 8.70% moisture as determined in a vacuum oven at 70° C. and less than 5 mm. Hg. pressure for 40 hours *(15)*. These vacuum oven conditions were used throughout the work.

[c] The glucose and sucrose were from National Bureau of Standards standard samples.

[d] Specimen weight refers to moist basis, except for sugars, which were dry.

[e] Based upon 1.835 *N*. potassium dichromate solution. This concentration was used throughout the work. The values in this column are means ± mean deviations.

[f] Standard deviation equals $\sqrt{\Sigma\Delta^2/(n-1)}$. This refers to deviations of individual *D* values from the means given in column 4.

[g] Theoretical gram-equivalent weights for glucose and sucrose are, respectively, 7.506 and 7.131.

precision of this oxidimetric procedure. This is shown by the results for *D* of glucose and sucrose, for which perfect uniformity of the sample may be assumed. The standard deviations of replicates from the mean were in these cases 0.12% and 0.09%, respectively, as shown in Table 1. These deviations include the relatively small errors involved in the titrimetric and volumetric processes.

It is of interest to note that the equivalent weights obtained for glucose and sucrose correspond to 99.4% and 99.2%, respectively, of theory, assuming CO_2 as the end product. The dichromate was found to be within 0.01% of nominal concentration when checked against a National Bureau of Standards standard sample of potassium dichromate. These values are approximately 0.5% higher than those of Conrad and co-workers *(20)*, who used a technique in which the dichromate solution is boiled for one hour.

ACCURACY

The accuracy of the method may be regarded as the extent to which a moisture value agrees with that obtained using the reference method, regardless of variations in composition. The accuracy may therefore be expected to differ for each material.

Dehydrated potatoes. The variation in dichromate factor with potato samples is shown in Table 2, column 5. These samples differed in variety, place of origin, method of preparation, age, storage conditions, SO_2, ash, protein, and of course, moisture content. Those samples having "unusual" characteristics not likely to be ordinarily encountered in testing were omitted from Table 2 so that the results would have more general significance.

The unusual characteristics do not always cause excessive error, however, as can be seen from Table 3. Only one of the very old samples, QM25, showed excessive error; and even abnormally high protein content,

TABLE 2

Dichromate factor F and moisture results for various potato samples

Sample	Variety or origin	Year grown	Remarks	Dichromate[h] factor F	Moisture, vac. oven	Moisture, calc.[j]	Moisture error
				g. (dry)/ml.	%	%	%
10	N. Y., N. J.	1948	Unpeeled	0.01342	7.9	8.2	0.3
11	N. Y.	1948	Unpeeled	0.01337	7.2	7.1	0.1
12	N. Y.	1948	Unpeeled	0.01337	7.2	7.1	0.1
23	N. Y.	1948	Unpeeled	0.01339	7.5	7.6	0.1
24	Minn., N. D.	1948	Peeled	0.01324	8.6	7.6	1.0
27	Minn., N. D.	1948	Peeled	0.01343	8.3	8.6	0.3
30	N. J.	1948	Unpeeled	0.01353	9.5	10.5	1.0
50	Idaho	1948	Peeled	0.01336	8.4	8.3	0.1
72	Maine	1948	Peeled	0.01348	8.0	8.7	0.7
73	Maine	1948	Peeled	0.01350	8.4	9.2	0.8
309-09-9	Kern Co., White Rose	1950	Air, 72° F.	0.01340	7.2	7.3	0.1
32	Kern Co., White Rose	1950	Air, 72° F.	0.01338	6.6	6.6	0.0
225-58-3	Idaho Russet Burb.	1950	Air, 72° F.	0.01322	6.1	5.0	1.1
309-09-16	Klamath Russet Burb.	1950	Air, 72° F.	0.01348	8.2	8.9	0.7
01	Stockton White Rose ?[i]	1950	SO_2, 250 p.p.m.	0.01332	8.2	7.8	0.4
309-36-5	Sta. Maria Russet	1950	SO_2, 700 p.p.m.	0.01341	9.6	9.8	0.2
309-36-1	Sta. Maria Russet	1950	SO_2, 0 p.p.m.	0.01339	11.2	11.3	0.1
309-36-3	Sta. Maria Russet	1950	SO_2, 600 p.p.m.	0.01330	9.6	9.1	0.5
309-33-1	Sta. Maria Russet	1950	SO_2, 2800 p.p.m.	0.01331	7.5	7.0	0.5
283-04-1K	?	1949	N_2, —30° F.	0.01336	6.8	6.7	0.1
02	Stockton White Rose ?	1950	Air, 72° F.	0.01338	8.2	8.2	0.0
03	Stockton White Rose ?	1950	Air, 72° F.	0.01338	8.3	8.3	0.0
04	?	1950	Air, 72° F.	0.01337	8.8	8.7	0.1
05	Idaho Russet ?	1950	Air, 72° F.	0.01329	9.3	8.7	0.6
			Means	0.01338	8.19	—	0.37
			Standard Deviation	±0.57%			

[h] The F values in this and subsequent tables are the means of quadruplicate oxidation and triplicate vacuum oven values.
[i] Question mark signifies commercial product whose origin is either unknown or uncertain.
[j] Moisture values calculated using mean F equal to 0.01338 for all samples.

as in sample 31, does not appear to invalidate results. On the other hand, extensive loss of juice, and with it the soluble constituents, such as had occurred in sample 60 because of pressing before dehydration, appears to lead to excessive error. This was also observed in the case of a sample of fresh peas which had been pressure-cooked with an equal weight of water, resulting in extensive leaching of the soluble constituents, and causing a moisture error of 2.4%.

If the samples listed in Table 2 can be considered as representative of dehydrated potatoes in general, it follows that the moisture content of a random sample may be determined by this method, using the mean dichromate factor, F, of 0.01338 g. per ml., with a mean error of 0.37% moisture.

It should be stressed that the intention of the writers was to develop a technique for materials in the higher moisture range. However, dehydrated potato samples of known histories were available and offered a convenient means of studying the behavior of potatoes of any moisture content, the assumption being that such materials are not oxidized during drying sufficiently to change the dichromate factor. This is supported by studies on potatoes (and carrots) in a pilot plant tunnel dryer. Samples removed at ten intervals from 78 to 6% moisture content showed no change in dichromate factor. Also, dehydrated peas had the same factor as fresh peas. This is to be expected for acceptable dehydrated foods, inasmuch as taste and odor are usually much more sensitive than chemical test methods in foods.

From the results for F in Table 2, which refer to samples whose average moisture content was 8.19%, it may be calculated that the mean moisture error for normally moist potatoes containing 78% water would be 0.09%. At this moisture content an individual dichromate factor would have to differ from the mean value of F in Table 2 by 3.6% to give a moisture error of 1%.

Of the composition variables affecting F, ash content is the most obvious. This point was accordingly investigated with samples for which analytical data had been obtained by Treadway, Willits, Heisler, Ross, and Osborne *(21)*. Ash content and F values for these samples are given in Table 4. The correlation, $\Sigma\ \Delta A \Delta F / \sqrt{\Sigma(\Delta A)^2\ \Sigma(\Delta F)^2}$, wherein A is the deviation of individual ash values from the mean, etc., between these two sets of values was found to be 91%, indicating almost complete interdependency. However, when the dichromate factor was expressed on an ashless basis, as in column 6, Table 4, the standard deviation of values from the mean was 0.39%, which is definitely higher than for replicates of one sample, Table 1. The correlation between F and protein content, column 3, Table 4, was also high (92%) but it is evident that with the possible exception of the two extremes the F values, already corrected for ash, should not be corrected for proteins. If sample 31, unusual in that it had the highest protein content of 100 samples, were omitted, the improvement would be considerable.

TABLE 3

Effect of unusual characteristics in potatoes upon dichromate factor F and upon moisture error

Sample No.	Unusual characteristics[k]	Dichromate factor F	Moisture error[l]
		g. (dry)/ml.	%
31	Highest proteins, 13.31%, in 100 samples	0.01355	1.2
60	Low proteins 7.2%, low ash 3.1% due to pressing	0.01316	1.5
QM25	Stored 6 yrs. in N_2 at 33° F.	0.01313	1.7
142	Stored 7 yrs. in N_2 at 75° F.	0.01325	0.9
395	Stored 6 yrs. in N_2 at 75° F.	0.01330	0.5

[k] Samples 31 and 60 were especially selected for abnormally high and low protein contents. No. 60 had lost much of its juice, and with it, soluble ash and proteins, by pressing prior to dehydration.
[l] These moisture errors resulted when using the mean F equal to 0.01338 of Table 2 for these samples.

Fresh peas. Dichromate factors for pea samples varying in variety, size, crop, and maturity are shown in Table 5, along with moisture errors resulting from the use of the mean dichromate factor. These samples had moisture contents approximately equal to those of

TABLE 4

Effect of ash and protein content of potatoes [m] upon dichromate factor and moisture error

Sample No.	Ash [n] content	Protein [n] content	Dichromate factor F	Moisture error for F = 0.01342	Dichromate factor F [o]	Moisture error for F = 0.01283
	%	%	*g. (dry) /ml.*	%	*g. (dry, ashless) /ml.*	%
31	4.36	13.31	0.01354	0.8	0.01295	0.9
72	4.84	12.13	0.01348	.4	0.01283	.0
73	5.05	12.06	0.01350	.5	0.01282	.1
30	5.15	11.44	0.01353	.7	0.01283	.0
11	4.36	10.94	0.01337	.3	0.01279	.3
10	4.46	10.88	0.01342	.0	0.01282	.1
23	4.30	10.81	0.01339	.2	0.01281	.2
12	4.24	10.81	0.01337	.3	0.01280	.2
27	4.36	9.56	0.01343	.1	0.01284	.1
50	3.84	8.94	0.01336	.4	0.01285	.2
24	3.56	8.63	0.01324	1.2	0.01277	.4
Means	4.41	10.86	0.01342	0.44	0.01283	0.23
		Standard deviation: 0.69%		Standard deviation: 0.39%		

[m] These samples had a higher average ash content than the 3.9% of the samples of Table 2 and thus show a higher value for F.

[n] For protein and ash methods see ref. 20.

[o] F (ashless) = F x (100 — % ash).

freshly picked peas but had been stored at —10° C., either in air or under vacuum.

It may be seen that the standard deviation of F values from the mean is much larger for peas than for potatoes. The large dispersion of F values for peas resulted in only a moderate mean moisture error of 0.43% (last column) because of the relatively high mean moisture content which was equal to 77.2%. From these results it may be calculated that the mean moisture error for dehydrated peas of 8% moisture content would be 1.7%. This means that extreme errors of some 4% would be expected.

An attempt was made to ascertain the reason for the large dispersion of F values for peas but no significant correlation with ash or protein was found. The ash values ranged from 2.2 to 3.8%, average 3.2; and the protein values ranged from 26.2 to 32.6, average 29.6%.

It is of interest to note that the individual dichromate factors appeared to be fairly characteristic of maturity for the 18 samples of peas studied.

SUMMARY

A rapid, simple and precise oxidimetric technique employing standard potassium dichromate solution with electrometric back-titration has been developed. Carbohydrates such as glucose and sucrose are quantitatively oxidized to 99.4 and 99.2% of theory, and vegetables are reproducibly oxidized. The reproducibility for potatoes, peas, glucose, and sucrose was found to be 0.10, 0.13, 0.12, and 0.09%, respectively. These are the standard deviations of 10 to 12 replicates from the means. The time for a complete determination, exclusive of sample preparation such as 20-mesh grinding or slurrying, and weighing, is 5 to 10 minutes, usually permitting some 12 determinations per hour.

The oxidimetric procedure was applied to the rapid determination of moisture content of potatoes and peas. Using for potatoes and peas, respectively, mean dichromate factors of 0.01338 and 0.01373 g. of dry material per ml. of 1.835 N. dichromate which were determined from a considerable number of samples of each material representing different batches, crops, and varieties, it was possible to calculate water contents and compare them with vacuum oven results.

The mean errors for the dehydrated potatoes and the fresh (frozen) peas studied were 0.37 and 0.43% moisture, respectively. These errors arise from variations in composition and include vacuum oven mean deviations of 0.1 and 0.25%, respectively. From these values it can be calculated that the errors for fresh (or

TABLE 5

Dichromate factor F and moisture results for various pea samples [p]

Sample No.	Variety [q] and size	Year grown	Maturity [r]	Dichromate factor F	Moisture content		
					Vac. oven [s]	Calculated [t]	Error
				g. (dry)/ml.	%	%	%
1	TL-3, 4	1950	Immature	0.01410	81.5	82.0	0.5
2	Ro-5, 6	1949	Mature	0.01407	79.7	80.2	0.5
3	Or-3, 4	1950	Immature	0.01407	81.0	81.4	0.4
4	FM-2	1949	Immature	0.01406	84.5	84.9	0.4
5	Or-5, 6	1950	Mature	0.01399	76.8	77.2	0.4
6	TL-5, 6	1950	Mature	0.01394	75.7	76.1	0.4
7	Or-5, 6	1950	Mature	0.01379	78.4	78.5	0.1
8	TL-5, 6	1950	Mature	0.01365	77.2	77.1	0.1
9	FM-6	1949	Mature	0.01355	78.2	77.9	0.3
10	Or-5, 6	1950	Mature	0.01346	74.4	73.9	0.5
11	TL-5, 6	1950	Mature	0.01342	73.9	73.3	0.6
12	Wy	1950	Mature	0.01339	76.5	75.9	0.6
13	Wy	1950	Mature	0.01336	78.6	78.0	0.6
14	Or-5, 6	1950	Mature	0.01334	76.5	75.8	0.7
15	FM-7	1950	Overmature	0.01331	74.1	73.3	0.8
16	TL-7	1950	Overmature	0.01321	72.4	71.3	1.1
17	FM-6, 8	1950	Overmature	0.01317	73.9	72.8	1.1
18	FM-7	1950	Overmature	0.01315	76.7	75.7	1.0
Mean, excluding overmature samples				0.01373	77.2		0.43 [t]
Mean, including overmature samples				0.01361			
Standard deviation including overmature samples				±2.54%			

[p] All pea specimens were taken from slurries prepared with water in a Waring Blendor to contain approximately 85% moisture. The moisture contents in the table refer to the peas before slurrying.

[q] TL: Thomas Laxton; Ro: Rondo; Or: Oracle; FM: Ferry Morse; Wy: Wyolla. These peas were all frozen immediately after picking and shelling with the following exceptions: Sample 13 was delayed for 2-12 hours before freezing; all FM samples were vacuum packed dry before freezing; Samples 17 and 18 were delayed for 2-12 hours before vacuum packing.

[r] These terms correlated fairly well with Tenderometer readings.

[s] Specimens were predried for 2 hrs. at 70° C. in a forced-draft oven.

[t] These values were calculated using the mean F of 0.01373. This F does not include the overmature samples, which were large, woody and unmarketable, and which were also excluded from the mean error.

moist) potatoes (78% moisture) and dehydrated peas (8% moisture) would be 0.1 and 1.7%, respectively. Thus, the method has optimum application at higher moisture levels, and in that range mean dichromate factors may be used. For dehydrated materials, it will probably be necessary to determine the dichromate factor for the batch or crops of interest, unless approximate values suffice for a particular application.

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Role of Food Industry in the Production of New Products for Naval Subsistence[a]

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New developments in foods needed by the U. S. Navy and the role of the food industry in the development of such items as premixes, precooked frozen foods, prefabricated meats, and dried milk is described.

Commissary research for the United States Navy is conducted by the Commissary Research Division of the Naval Supply Research and Development Facility which is located at Bayonne, N. J. The only activity, in the Navy, which does research in the fields of food and food equipment, the division finds itself responsible for naval research in nutrition, food preservation, food preparation, food preparation equipment, and food service equipment. Even though this research is limited to those problems which are of particular and special interest to the Navy, the demand is still tremendous and the money and personnel allotted are too small for the job which has been and which remains to be done. To overcome this deficiency, it has been necessary to turn to industry for help and to utilize the excellent research facilities which they have made available.

We have indeed been fortunate that industry has responded wholeheartedly in our request for help. From the beginning they have been only too glad to give every assistance and to pursue those lines of food research of peculiar interest to us. This cooperation usually follows one of three procedures:

(1) Our research scientists will work a problem down to its bare requirements for submittal to interested industrial agencies who will attempt to find a solution.
(2) We will develop a solution of our own, then submit it to industry for comment and evaluation.
(3) Industry will come to us with new food products, new equipment, or new ideas which they believe have an application in the solving of our problems.

All of this has brought about a working relationship which has been of benefit to both the Navy and to Industry.

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To be specific, a few cases of mutual assistance bear mentioning:

(1) The development of the Navy Recipe Service.
(2) The development of precooked frozen foods for use afloat.
(3) The improvement and increased utilization of dried whole and skim milk.
(4) The use of prefabricated meats for shipboard feeding.
(5) The development of premixes.
(6) The development of more efficient galley equipment.
(7) Modification of packaging methods to give maximum saving of space.

There are many others but these examples will suffice to give a reasonable and accurate picture of the role which industry plays in Navy subsistence research.

NAVY RECIPE SERVICE

While the old Navy cookbook was considered the Bible of the aspiring young cook, and did its job well, it did not lend itself to inexpensive changes and corrections which were necessary to keep Navy subsistence abreast of the times. To correct this, it was decided to place the Navy recipes in a card-file form and the Navy Recipe Service was organized for this purpose. Recipes from the Navy Cookbook, prominent institutions' cookbooks, and private files were compiled and given preliminary testing in the commissary research test kitchen. Those recipes successful in these preliminary tests were further tested for acceptability in the General Mess of the Navy Supply Corps School at Bayonne. Through the National Security Industrial Association, the Navy Cookbook Task Committee had been organized and the recipes were next turned over to this committee. Members of the committee checked all of the recipes in their test kitchens and made recommendations as to modifications. Differences in opinion with the industrial representatives were ironed out in conference, final acceptability tests were run, and the recipes were considered ready for printing and distribution to the Fleet.

Precooked frozen foods. In the utilization of precooked frozen foods, various likely recipes were made up according to standard Navy formulas then modified to permit freezing. Those products which were successful were given over to a frozen food manufacturer who worked out the needed commercial modifications. The resultant products were given extensive operational testing to determine those changes necessary to make them practical and acceptable for Navy feeding.

Dried whole milk. Getting more milk into the bluejacket's diet is one of the major problems of Navy subsistence. To assist in this, representatives of the dry milk industry were called on for suggestions. As has always been the case when we have gone to industry, the response was immediate and positive. The result has been means of greatly increasing shipboard acceptability of powdered dry milk and a product much improved over that used by the Navy in World War II.

Prefabricated meats. To conserve space, save time, and ease the burden of the Navy cook, the meat industry has gone to special pains to develop prefabricated meats especially tailored to our needs. This included special cuts, meat cut to Navy portion sizes, special packaging, etc.

Premixes. Many vessels, especially those in the small size categories, have had to forego at sea the pleasures of pastries, sweet rolls, and cakes. The great time necessary to measure out and mix ingredients plus a frequent lack of baking skill on the part of the bakers have been responsible for this. To overcome these difficulties, it was felt that the growing field of premixes, with their resultant ease and short time of preparation, should be utilized. Industry was approached with a list of our requirements; where commercial products were not available, they went to work to develop them or modify existing products to our desires. The makers of premixed soup gave similar cooperation.

Equipment

In the food preparation equipment and food service equipment fields we have had to lean heavily on the accomplished designers and expert engineers of the cooperating industrial organizations. Given our requirements and limitations they have developed the needed equipment. Given our problems they have designed new types or modified existing equipment to our needs and desires.

SPACE SAVING PACKAGING

Space, aboard Navy vessels, is particularly critical. The problems of developing space saving equipment, packages, and procedures seem to be always with us. Premixes, prefabricated meats, precooked frozen foods, dehydrates and concentrates have all contributed to the saving of essential cubage. In addition, industry has worked with us on special packaging which will save space, fit neatly on the standard Navy pallet, stand wear and tear, and be readily divisible in units most economical for Navy feeding.

Good progress has been made in solving those problems related to Navy subsistence but there is still much to be done. In the near future we must:

(1) Improve, even more, weight and space savings in rations.
(2) Eliminate all preparation failures caused by inexperienced cooks.
(3) Give preserved food a taste as much like its fresh counterpart as possible.
(4) Develop forms of food which will require a minimum of heat, utilize a minimum of labor, contain no waste, yet provide meals better than ever before.
(5) Develop galley and food service equipment which will occupy less space, use less power, do a more efficient job, be subject to less mechanical failures, and require less skilled operators.

The progress of the past would not have been possible without the wholehearted cooperation of our friends in industry. And this cooperation must continue, as we know it will, if commissary research is to keep abreast of other Navy changes and developments.

The Consumer's Reaction Toward the Food Industry and Its Products[a]

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Some possibilities for the improvement of the food industries' services to the homemaker-consumer are discussed.

The food industry has the challenge of satisfyingly serving the American consumer. This is a challenge because the American consumer's food habits are an outgrowth of the mixtures of cultures resulting from immigration. Every family is an individual unit with its likes and dislikes for food influenced by nationality, custom, tradition, and habit. The food industry has the problem of supplying the consumer at a fair price with many types of good quality foods that are pleasing in both appearance and taste. This is important because food preferences are a fundamental influence in the nutritional status of the American consumer. In addition, the food industry has the problem of supplying a balanced variety of foods so that the American people may have an adequate diet which contains in readily utilizable form all of the nutrients needed by the body for the maintenance of good health.

The supplying of food to the consumer is more important than ever as we change from a rural to a more urban nation. According to the 1950 census, the rural population is now only about 36% of our total population. The modern homemaker-consumer is at the mercy of the food processor because she has little chance to produce her own foods or to buy directly from the farmer-producer. As a consequence, the food industry has more to do with the health of the American people than is apparent to the casual observer. Great progress has been made in supplying the homemaker with a large variety of food products from which she may make selections to meet her family's needs.

In fact, one might ask whether the homemaker could wish for anything more when she is able to find on the grocery shelves row after row of different brands of various types of canned foods; packaged cereals, breads, frozen fruits, and vegetables; canned and packaged meats; prepared foods for the family pets; packaged instant mashed potatoes; and prepared mixes too numerous to mention. The homemaker it seems is never satisfied. She is constantly seeking new and better products.

The modern homemaker is becoming increasingly discriminatory as a buyer-consumer largely because of her expanding educational opportunities. Most young women and some of our young men are electing as a part of their educational programs instruction in health, nutrition, child care and feeding, and family economics, all of which is commonly labeled homemaking or home economics education. In these courses they are receiving instruction in the fundamentals of good nutrition; basic principles of food cookery with emphasis on selection, preparation, serving, conservation, and storage of food for the family; information in regard to selection and purchase of goods and services for the home; and constructive advice on the management of the home for the conservation and wise use of energy, time and money.

According to figures released by the United States Office of Education for the year 1948-49, there were nearly 1,700,000 students enrolled in these homemaking education classes in the high schools in the United States. Besides this, our public schools are offering classes for adults which enable them to secure information that will assist them with their problems as consumers of food and fabric. This is an important fact for processors of food products to keep in mind. It means that the majority of the young homemaker consumers are well informed and have factual information upon which to make wise decisions in purchasing food products. Considering, in addition, the fact that the general educational attainment level of these homemaker-consumers is constantly rising, it becomes clear that they are becoming increasingly discriminating and discerning buyers.

The modern day educated homemaker-consumer reads the labels on the cans for information and is always asking herself, "Which brand shall I select? Which product gives me the best return for my money? How long have the foods been on the shelves or in storage? Are the vitamins and minerals needed for good health maintained?" The labels on many of the present day products help her only in a limited way. She can find on the labels of the canned fruits and vegetables the weight, in most cases the number of cups in the container, and the type of syrup used. The brand name means little to her unless she has used the product and has become familiar with its qualities and characteristics. She does not know how much of the vitamin content of the food remains.

With the mobility that family members now have, with families changing their place of residence not only within a state but from one state to another, there is an increasing need for more informative labels on food products offered for sale. The consumer is interested particularly in knowing the quality of the product. If food processors could adopt specific standards for first and second quality and use a symbol for each the consumer would become forever grateful. Consumers would then be able to buy the standard grade needed for the purpose at hand. With national grade labeling and an education program for informing the public, food processors would earn the confidence and gratitude of their buying public. The opportunities as food processors carry with them a degree of moral responsibility especially as it relates to a sanitary product of known quality that preserves maximum food values in every item processed.

The recipes that are found on many products are helpful and useful. It is surprising that with all the good cookbooks avalaible many homemakers turn to the

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recipes found on the label of the processed product. Consumers have learned that the recipes on the products are reliable.

The American way of life seems to call for the simplified way of doing things. The consumer now has available in her market a wide variety of prepared and partially prepared foods. Practically every type of baked product a homemaker might wish to prepare for her family is now obtainable in the market in the form of a mix. The prepared mixes are also available for puddings, frosting, fudge, soups, and ice cream. Their acceptability is shown in part by their increased use by the homemaker who has employment outside the home as well as by the young homemaker with small children who hasn't time to devote to the full preparation of foods that she serves. The homemaker feels that she is saving the time it would take her to measure out the ingredients. The homemaker is interested not only in time-saving devices but in the quality and quantity of the products purchased for the amount of money expended. Improvements have been made in mixes since they were first put on the market but further research is needed to secure better and less expensive products. Food processors might spend much time and care in testing the acceptability of a product before placing it on the general market rather than to build up buyer resistance to the product because of a fault which could have been corrected.

Many of the foods on the market are packaged in some form. The homemaker-consumer is interested in the container for various reasons. She wants the container to be of a convenient size and easy to handle, to fit into a standard cupboard, to be large enough to contain a sufficient amount for the family, to be easy to open, and one which will retain the freshness of the product. Food processors need to work more closely with cabinet makers in determining the size of containers. Some of the large cereal boxes are very inconvenient to store. A plea could be made for standard size cereal boxes. It seems that some formula could be worked out to package the cereals according to the number of servings to be found in each box. If, for example, a standard of one-half cup to a serving were used and the box marked to indicate the number of such size servings contained therein it would be helpful to the consumer buyer. This of course should always be in addition to the information given on weight.

Soda crackers wrapped in small packages within a large container have brought joy to the homemaker. We now can have crisp soda crackers and graham crackers available at all times. The homemaker would like to have all cracker products wrapped in small packages within a large container.

Opening packaged goods is an annoying little task. A little longer and stronger tape on the packages that now have them would help. A strong cord sealed in the outside wrapping might be devised by your engineers to make package opening an easier operation.

The friendly butcher seems to be fast disappearing. A real butcher, the homemaker's interpreter and friend, may now be seen only through an aperture after pressing a little button near a sliding panel. Self help meat service seems to have been forced upon the consumer. Some homemakers like it, others do not. The only advantage to the homemaker seems to be that she does not have to wait in line or take her turn to be waited upon. The objection that homemakers have to packaged fresh meat is that their selection must be made from what has been prepared for sale. The meat is placed on heavy cardboard so that the consumer cannot see the underside. Often the sticker is placed over the bone which thereby conceals rather than informs. Today's consumer-buyer wants to be informed. If packaged meat is to be sold successfully, the product visible to the purchaser must be honestly representative of what is in the entire package. There are many homemakers who will drive a little farther to shop at a store that still retains the old fashioned meat maket where they can see exactly what they are buying.

Commercially frozen fruits and vegetables are one of the highlights of the twentieth century. Here again, the consumer is dependent upon the food industries for securing the highest type quality and using the best known method for freezing the product so that the maximum of food values is retained. As a whole, homemakers appreciate what has been done in supplying tasty frozen foods that are easy to prepare, attractive, and of good flavor. Homemakers would like a tasty frozen fruit salad, packaged to serve two or four persons.

Busy office girls and bachelors who live alone and prepare some of their own meals would welcome a well balanced attractive meal all packaged in one container. Saturday shopping would be simplified for them, for all they would have to do would be to select different types of complete meals for each day in the week. When returning home from work it would be necessary only to open the package and, presto, they would find vegetables, meat, salad, maybe a roll, and dessert ready to be cooked.

Frozen foods put up in servings for two might prove to be a way of increasing sales of the product since apartment refrigerators are very small.

With reference to fruit juices, there must be an improved way of capturing and retaining that fresh orange taste in the frozen juice.

Different types of dried fruits packaged together would be convenient for the homemaker. This has been done to a limited extent but such packages are not found in the average store.

Today, homemakers are more concerned over the high cost of foods than they are over the varieties of foods and types of mixes. The price of the food rather than the kind and quantity available will be the limiting factor in the amount of food that is sold. With higher food prices the consumer who knows food values will turn to the most nutritious foods and will think in terms of what will give the best return for her money.

Dried milk is being used by more homemakers to conserve the family budget. Dried eggs might be used by homemakers in baking if they were put on the market in attractive packages. To promote their sale, an educational program would have to be conducted. This could be done by efficient home economists and advertising agencies in cooperation with the public schools.

Food cookery is an art where the homemaker strives constantly to excel. It needs to be strengthened and maintained as a means of increasing the bonds of family life.

Practical Determination of Size Distribution of Suspended Particles in Macerated Tomato Products[a]

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A method is presented for the separation from tomato juice, puree, catsup, paste, etc. of the particles over 0.1 mm. in diameter into five fractions. The amount of solid particles in each fraction is then determined by the volume which they occupy in water after standing at least 15 hours. The usefulness and limitations of the method are discussed.

The proportion and size distribution of suspended tissue particles (insoluble solids) is of significance in many tomato products. In tomato juice such suspended particles must not show a tendency to settle and thus cause the formation of a layer of clear yellow liquid on top. In tomato sauce, puree, catsup, and paste, the consistency (ease of flow and lumpiness) of the product is an important factor in determining commercial value. The proportion and size distribution of suspended solids play a part in determining the physical behavior of these products.

For these reasons it was considered desirable to develop a method for the determination of the size distribution of suspended particles in such food products. The simple practical method described below has been found suitable for the determination of the size distribution of particles which have average diameters larger than 0.1 mm. This fraction usually represents over 50% (by weight) of the total suspended solids.

EXPERIMENTAL

For the separation of suspended particles of different sizes, a set of five U. S. Standard sieves with 20, 40, 60, 100, and 140-mesh openings are used. The nominal openings of these sieves and the assumed average diameter of the particles which they retain are shown in Table 1. For particles which passed through one sieve but not the next one, an average effective particle diameter half way between the diameters of the openings of the two sieves was assumed. For the particles which stayed on the sieve with the largest openings, the average effective particle size (diameter) was assumed to be 50% over the diameter of the openings.

TABLE 1

Specifications of sieves used, and assumed effective diameters of average particles retained by each sieve

Sieve No.	Nominal sieve opening		Assumed average diameter of average particle
	inches	*mm.*	*mm.*
20	0.0331	0.840	1.260
40	0.0165	0.420	0.630
60	0.0098	0.250	0.335
100	0.0059	0.149	0.200
140	0.0041	0.105	0.127

[a] Approved for publication as Journal Paper No. 874, New York State Agricultural Experiment Station, Geneva.

The separation is performed as follows: The sieves are fitted together in order of decreasing openings with the 20-mesh sieve on the top and the set is placed in a sink. To a 100-ml. sample of well-mixed tomato juice about 100 ml. of distilled water is added and the mixture is poured slowly on the top sieve from such a height that the angle of the stream is not greater than about 45°. The flask is rinsed to transfer to the sieve all tomato particles and the set of sieves is slowly swirled until the bulk of the liquid from the top sieve has passed on to the next sieve.

When more concentrated tomato products as puree or paste are investigated, a sample of definite weight is diluted with water to give 100 ml. of slurry of about 5-6% total solids content and this mixture is used as directed above.

A stream of water from a rubber tube terminating in a tapered nozzle is used to facilitate the washing through of the tomato particles. A 4-foot head of water will give the desired pressure. To prevent excessive spraying and splashing, the flow of water is governed by a pinchcock. After most of the liquid has drained through, the top sieve is lifted off and washed in the following manner: The sieve is held at an angle of about 45° as close to the sieve below as possible so that all water dripping from the top sieve is caught on the next one. The particles are now washed by introducing the distilled water from below the screen at an angle of about 30°. The sieve is rotated slowly and at the same time the material on the sieve is washed from the center to the lower part of the sieve. The screen is rotated 3 times with constant washing, and then all the liquid is allowed to drain from the sieve. Now the particles collected are washed with the aid of a funnel into a 250-ml. graduated cylinder. The funnel is rinsed and the contents of the cylinder are made up to 250 ml. with water and mixed. The cylinder is then allowed to stand for at least 15 hours, usually overnight.

When the amount of particles remaining on any given screen is large, the mesh may become clogged so that smaller particles which would normally pass through the screen are held back. In such instances it helps to allow the water to drain off after each rotation of the sieve.

The same procedure is followed with all the other sieves. The particles smaller than the openings of the holes in the finest sieve will run into the sink with the tomato serum and the wash water. The procedure is then repeated with a duplicate sample.

The following day (or after at least 15 hours) the volumes of the sedimented particles in the cylinders are read. For tomato juice samples the total volume is usually 2 to 3 times the volume of the sample. The duplicates should agree within 20%. The averages for the pairs representing the different fractions are calculated. The particle size distribution may be illustrated by curves or expressed by the value "P" which is the weighted average diameter of the average particles present in the 5 fractions. This "P" value is calculated by multiplying the volume of the particles in the cylinder by the assumed average diameter of the particles of the fraction as given in Table 1. The sum total of these 5 numbers for the 5 fractions is then divided by the sum total of the volume (ml.) of precipitate found in the five fractions.

Some of the results obtained are presented in Table 2.

RESULTS AND DISCUSSION

Shape of solid particles. The particles of tomato tissues suspended in macerated products like juice, puree, paste, etc. are neither uniform nor regular in

shape. Under the microscope and with proper staining, many of these particles exhibit torn, ragged edges *(3)*. Thus the effective size of the particles, as here understood, is defined by their ability to pass through a screen rather than by their maximum diameter.

Effect of leaching on suspended particles. In the official method for the determination of insoluble solids in tomato products *(1)*, the suspended solids are washed repeatedly with hot water of unspecified temperature and amount. Such treatment results in the progressive dissolution of some parts of suspended solids which thereby change in composition, weight, and size. In the present method cold water has been used for washing the insoluble solids. This results in less leaching and thus also in less change in the shape of the particles. Our interest was in the suspended particles as nearly as possible as they existed in the product and not in their hot water-insoluble fraction as sought in the official method.

Significance of the discarded fraction of particles below 0.1 mm. in diameter. There appears to be an extent of arbitrariness in not taking into account the particles which have passed through the smallest sieve and thus have effective diameters below 0.1 mm. This borderline value has been selected because suspended particles with diameters above this value will easily sediment in water and thus allow an assessment of the distribution of particles in the different fractions. Particles which have passed through the 140-mesh sieve and thus have smaller diameters do not show a regular tendency to settle in the cylinders. They can be estimated by volume after a certain extent of centrifuging *(3)*, or by their dry weight. While both of these methods have been used in our work, it is felt that the complications introduced by the use of such determinations are not usually warranted in the present practical method. We shall return to this point later.

Rate of sedimentation. In order to determine the length of time required for the sedimentation of the suspended particles in the different fractions, we have studied the changes in the volume readings throughout a 24-hour period. The large particles which stayed on the 20-mesh sieve sedimented rapidly and gave in 4 hours readings which did not change during a further 20-hour period. There was some further sedimentation, after 4 hours, of the particles which stayed on the two smallest (100- and 140-mesh) sieves. The effect, however, is most pronounced with the medium-sized particles, especially those staying on the 60-mesh sieve. Here the sedimentation was slower than with either the larger or the smaller particles, and at least 10 hours were required until a constant reading could be obtained. It is on the basis of these observations that overnight settling or a minimum period of 15 hours is recommended in the present method.

Packing. The possible packing of the suspended particles was investigated by placing into 250-ml. graduated cylinders increasing proportions of a slurry of the separated solids of a given particle size range. The results indicated that the final volume attained after sedimentation was indeed affected by allowing different amounts of the particles to settle for 15 hours. However, the effect was proportional to the heights of the final columns and thus can be expressed by simple factors. For the five fractions of solids, in the order of decreasing average effective diameters, the correction factors found were 1.15, 1.27, 1.22, 1.30, and 1.10, respectively. It was felt that in the present practical method there would be no justification for applying such small corrections and therefore the matter of packing has been disregarded in the present work and in the results reported.

We have also found that the total of the volumes attained in water by the individual fractions was more than that obtained when these fractions were mixed and allowed to settle together. It is quite possible that the smaller particles are able to fit into the interstices between the larger particles thus accounting for the 10-20% reduction in volume.

TABLE 2

Distribution of particles over 0.1 mm. in effective diameter collected from samples

Code No.	Screen used in manufacture	Volume of particles retained on sieves					Total volume	Weighted average diameter of separated particles (P)
		No. 20	No. 40	No. 60	No. 100	No. 140		
Tomato Juice Samples								
	inches	*ml.*	*ml.*	*ml.*	*ml.*	*ml.*	*ml.*	*mm.*
1	unknown [c]	T [d]	20	99	107	61	287	0.26
2	unknown	T	3	48	60	88	199	0.21
3	unknown	T	5	40	62	80	187	0.21
4	unknown	T	81	51	67	37	236	0.37
5	unknown	0	3	86	81	53	223	0.26
6	unknown	T	16	84	84	43	227	0.24
7	0.020	4	63	53	66	37	223	0.36
8	0.023	5	76	71	73	37	262	0.37
9	0.027	8	100	65	62	32	267	0.42
10	0.033	14	78	84	69	37	282	0.40
11	0.045	20	63	68	61	36	248	0.42
12	0.060	34	58	66	63	35	256	0.46
13	0.060	26	40	60	71	48	245	0.40
14	0.023	8	66	60	55	43	232	0.38
15	0.023	6	43	40	62	40	191	0.34
Puree and Paste Samples								
16 (Puree)	unknown	2	59	62	35	16	174	0.37
17 (Puree)	unknown	—	13	62	68	36	179	0.26
18 (Paste)	unknown	15	38	71	44	23	191	0.41

[c] The openings in the screens used in the commercial manufacture of tomato juice are usually 0.020-0.023 inches in diameter.
[d] The letter T indicates traces.

Effect of temperature on rate of sedimentation and on final particle volume. The sedimentation is somewhat slower at a lower temperature. However, in tests made at 0°, 10°, 20°, and 30° C., the final readings after 15 hours were all within the usual experimental variation.

Reproducibility. There are a number of factors which may cause errors in this determination. Yet, we have found that after a few days' work an inexperienced operator was able to obtain satisfactory reproducibility. The error is always greater with the particles of large size (especially those staying on the 20-mesh screen) partly on account of the small readings in this fraction as well as on account of the visible variation in the plant structures which make up this fraction. In a study of 15 samples we found that the average difference between duplicate readings on the largest fraction was about 25%. For the four other fractions the average differences ranged from 7.7% to 11.7%.

Weight-volume relationship of the suspended particles. Throughout the years while this method was evolved, considerable data were accumulated on the "apparent specific gravity" of the suspended particles. Such determinations were usually made by first determining the final (settled) volume of a given fraction in the cylinder and then transferring the particles into a weighing dish and determining the amount of solids in the sample.[b] Due to the almost complete absence of sugars from these washed tissue particles, the drying is easy, and good end points are reached. From the weight of the sample the "volume per gram" can be calculated. Of course, such suspended particles do not fill the volumes which they attain in the cylinders, nor do they hold such proportions of water in the manner of some other materials like gums or starch. However, the effective volume of a particle in a tomato product is likely to be related to the volume of the same particles when suspended in water in the manner suggested by the present method. Thus the weight-volume relationship has practical significance even if its exact meaning is not clear at the present time.

The calculated volume of space (even if not the volume of water) taken up by 1 g. of tomato tissue ranged from 256 ml. to over 1500 ml. In general, the "volume per gram" ratio increased from the largest particles to the smallest particles which stayed on the 140-mesh screen. One might add, that by using the present definition, the volume per weight relationship for the particles under 140-mesh in diameter would be undefinable since most of these particles do not settle out of water. It is clear, however, that in addition to particle size, there are some other factors involved in determining this ratio since even in the same size range the "volume per gram" ratio changed several fold, depending on the sample analyzed. In any given sample the ratio for the particle size fraction which stayed on the 40-mesh screen was usually 30-60% of the ratio in the smallest particle size fraction. The reasons for this variation are not clear at the present time.

Effect of the screen used in manufacturing on particle size distribution. To ascertain the effect of the extractor screen used on the particle size distribution in the finished product, a series of tests was made on samples of tomato juice produced with screens having perforations of 0.020, 0.023, 0.027, 0.033, 0.045, and 0.060 inches in diameter. The results obtained are presented in Table 2 under codes 7 to 15. The samples marked 7 to 12 were manufactured on the same day from the same lot of tomatoes. As expected, the weighted average size of the particles (P) in these 6 samples increases as screens with increasingly larger openings were used.

The fraction which stayed on the 20-mesh screen increased in a regular manner while the proportion of particles in the next two size ranges seemed to pass through a maximum as the screen openings became larger. The "total volume," the sum total of the volumes of the five fractions, did not show any regular trends but varied between 223 and 283 ml.

It is clear from these tests that in addition to the screen openings, others factors are likely to influence the particle size distribution in such products. The maturity and texture of the fruit, the mechanical treatment before or after heating, the degree and extent of heat treatment before screening, the type of machinery used to perform these operations and the speed and adjustment with which it is operated, and the rate of feed are some of the factors which collectively might overshadow the influence of the size of openings in the manufacturing screen. It is also quite obvious from these tests that the bulk of the tomato tissue is reduced to particles much smaller in size than the openings in the screen used in the manufacture. By a three-fold increase in the diameter of the screen openings, the average diameter (of the particles of over 0.1 mm.) increased only about 30%.

Significance of results. The present method has been designed to give some information concerning the particle size distribution in certain tomato products without necessitating the use of complicated or expensive equipment. The definition of the various fractions can be improved by determining the weight-volume ratio in the different separated fractions *(3)*. Upon drying the various fractions and adding their dry weight, the total amount of solids of larger than 0.1 mm. size particles may be obtained. By determining at the same time the total suspended (insoluble) solids in the sample, the weight of the particles above 0.1 mm. in average diameter may be also expressed as the percentage of the total weight of (dry) suspended particles. However, as noted above, equal proportions of dry solids may represent widely different volumes of wet suspended particles.

Some tomato juice manufacturers feel that the proportion of large particles has a pronounced effect on what is designated by Crocker *(2)* as "mouth feel" and of course the present method will give information on the proportions of particles which might have such an effect.

[b] A sample of such dried washed particles was found to contain 37.2% "crude fiber," 26.1% protein (N × 6.25), 8.7% pectic polyuronides, and 2.8% ash. The 25.2% unaccounted for contains hemicelluloses and other polysaccharides.

The presence of some particles of larger sizes is desirable in tomato puree, catsup, paste, sauces, etc., and it has been a commercial practice for many years to produce these commodities with less maceration of the tomato tissue. The main use of the present method, as we see it, will be in enabling the operator to give a definition to the extent to which he desires to comminute the tomatoes. Inasmuch as it is quite clear that many factors influence the extent of comminution accomplished, some easy method for the objective determination of the particle size distribution might aid the manufacturer.

The fact that the particle size distribution of suspended solids might influence the consistency characteristics and related quality factors of tomato products is a comparatively new conception and therefore it is desirable to await the accumulation of some volume of data before any conclusions are drawn on such interrelationships. It is for this reason that we prefer to present the data in Table 2 without much comment. On the other hand, we desired to make this simple, practical method available for the use of others in order to allow the collection of information under a variety of conditions.

SUMMARY

By the use of sieves, the suspended particles in tomato products can be separated according to their effective diameter. The separated fractions can be then measured by the volume which they occupy in water in graduated cylinders. This method is suitable for only particles over 0.1 mm. in diameter since the smaller particles do not easily settle in water. The usefulness and limitations of the method are discussed.

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Peanut Butter. I. Roasting, Cooling, Blanching, and Picking of Peanuts[a]

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The times and temperatures required for roasting white Spanish peanuts from very light to very dark colors have been determined. Information is also presented on the cooling, blanching and manual sorting of these 20 batches of peanuts in relation to their original moisture contents and to the quality of the final product.

Peanut butter was first manufactured as a food product near the end of the nineteenth century and its production has been one of steady growth. It has become such a standard food that it accounts for the consumption of more than half of all the peanuts used for edible purposes in the United States. During the crop year 1949-50 more than 250 million pounds of peanuts were used in the United States in the manufacture of peanut butter, which had a retail value in excess of 100 million dollars.

Despite the age and size of the industry very little fundamental information can be found in the literature on the technology of the processes employed in producing this commodity or on the effects of the various processing variables on the quality of the finished product. The elements of the process appear simple, but actually, the unit operations commonly employed in converting raw peanuts into peanut butter produce highly complex chemical and physical changes in the former which affect the quality of the finished product. The industry and the consumer have been aware of various shortcomings in the product; for example, its tendency to separate into an oil phase and a meal phase. In addition, peanut butters differ in flavor as a result of conditions of processing, particularly roasting, and because of the rate and type of deterioration, such as staling and rancidification, during storage.

The purpose of this report is to present data on the roasting, cooling, blanching, and manual sorting operations customarily employed in the manufacture of peanut butter *(2)*, which will afford information regarding the character and quality of materials produced in these operations.

EXPERIMENTAL

Peanuts. The peanuts used in this investigation were No. 1 Grade, shelled, white Spanish peanuts *(3)* obtained from a commercial shelling plant in southeastern United States.

Roasting. Each product was prepared by roasting the peanuts in a two-bag (250-lb.)-capacity, natural gas-fired, radiant heat *(1)* roaster *(2)*. The temperature within the mass of roasting peanuts was measured by an indicating thermometer connected to a sensing bulb, which was installed within the roaster so that it would be at the bottom of the pile of peanuts. The roaster was preheated to various temperatures before introduction of the peanuts, to approximate conditions obtained in

[a] Report of a study made under the Research and Marketing Act of 1946.

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industrial operations. The conditions used in roasting, the types of roasts produced, and the moisture contents of the peanuts before and after roasting are given in Table 1. Variation of the temperature within the mass of roasting peanuts with the time of roasting is shown for three of these products (Figure 1).

Cooling. The peanuts were cooled immediately after they were dumped from the roaster into a 44 x 58 inch cooling car provided with a perforated screen, which supports the peanuts above the bottom of the car and permits the free passage of air. The average depth of the peanuts in the cooling car was about 5 inches. Cooling was accomplished by drawing air from the room at the rate of about 1100 cu. ft. of free air per minute downward through the batch of nuts by means of a heavy-duty exhaust fan. The conditions for cooling the peanuts and the results accomplished are shown in Table 2. Variation of the temperature within the mass of cooling peanuts with the time of cooling is shown for three of the products in Figure 2.

Blanching and Sorting. The testa (red skins) and germs (hearts) were separated by passing the roasted peanuts through a split-nut blanching machine of the ribbed-roll type *(2)*. In this device the shelled peanuts are divided into cotyledons (peanut halves or split-peanuts), germs, and testa by rubbing between

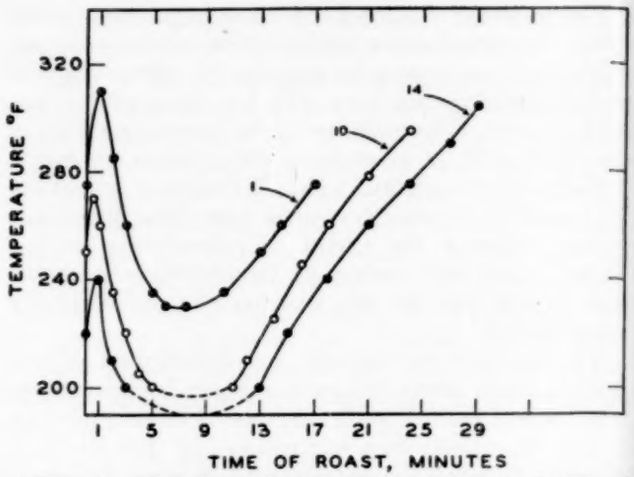

Figure 1. Variation of temperature of peanuts (measured at bottom of mass) with time of roasting. Curves represent light (1), medium (10), and dark (14) roasts.

TABLE 1

Results of peanut roasting tests

Batch No.	Raw peanuts	Roasting time	Roasting temperature			Peanut butter color		Moisture content of peanuts	
			Initial	Minimum	Maximum	Type	Designation[d]	Before roasting	After roasting and cooling
	lbs.	*minutes*	*° F.*	*° F.*	*° F.*			%	%
1	230	17	275	230	275	very light	11-E3	5.57	2.33
2	230	23	275	205	283	very light	11-J5	6.04	2.03
3	240	21	270	205	285	light	11-G5	5.95	1.71
4	230	22	275	200	285	light	11-G5	6.79	1.92
5	230	21.5	310	205	285	light	11-G5	6.31	1.94
6	230	25	260	200	292	light	11-G6	7.04	1.41
7	234	22.5	280	200	290	medium	11-F6	6.79	1.74
8	246	21	290	210	290	medium	11-F6	6.39	1.50
9	230	26	230	200	298	medium	11-F6	6.37	1.35
10	230	24	250	200	300	medium	11-F6	6.07	1.06
11	230	23	330	215	295	dark	11-J7	6.98	1.80
12	230	26	240	200	308	dark	12-K7	6.45	1.03
13	253	25	340	205	300	dark	12-L7	6.74	1.15
14	230	29	220	200	304	dark	12-J7	6.94	1.30
15	230	24	330	210	300	dark	12-I7	6.91	1.39
16	230	25	300	205	305	dark	12-L8	6.70	1.30
17	230	20	340	240	305	dark	12-L8	6.88	1.05
18	230	21	290	215	315	very dark	13-G9	6.20	1.25
19	200	17.75	300	250	320	very dark	13-F9	6.37	1.17
20	232	22.5	300	210	320	very dark	13-F9	6.27	1.08

[d] Refers to color plates in A. Maerz and M. Rea Paul, *A Dictionary of Color*. 1930, McGraw-Hill Book Company, Inc., New York.

TABLE 2

Range of conditions observed during the cooling of roasted peanuts

No.	Cooling time	Temperature of peanuts		Ambient temperature during cooling		Ambient relative humidity during cooling	
		Maximum	Minimum	Minimum	Maximum	Minimum	Maximum
	Minutes	*° F.*	*° F.*	*° F.*	*° F.*	%	%
1	22	273	91	82	84	65	71
2	23	271	86	80	86	46	50
3	19	275	85	79	83	36	41
4	17	266	78	80	86	47	50
5	21	285	95	84	86	48	50
6	17	280	85	78	83	50	52
7	19	295	95	82	85	42	48
8	17	302	104	82	83	50	50
9	22	295	86	78	84	54	60
10	22	295	85	78	85	53	53
11	19.5	285	90	85	88	43	44
12	22	314	85	80	86	54	56
13	19	310	100	83	85	43	43
14	26	305	86	78	85	60	66
15	17	335	95	84	86	46	48
16	19	315	85	80	90	38	46
17	17.5	285	110	82	84	32	32
18	17	320	95	82	84	46	54
19	20	314	88	80	85	64	80
20	22	338	99	85	86	50	51

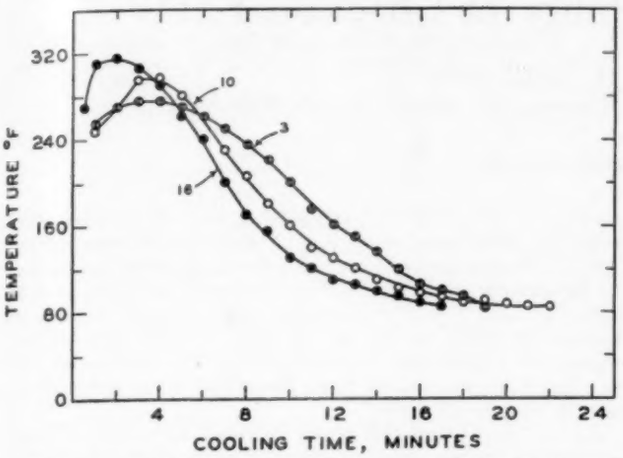

Figure 2. Variation of temperature of peanuts with time of cooling. Curves represent light (3), medium (10), and dark (16) roasts.

ribbed-rubber surfaces. The testa are aspirated away from the mixture, and the relatively small germs are separated from the cotyledons on an oscillating tray which screens out the germs. The objectionable material in the split-peanut portion, including unblanched and/or discolored nuts and foreign matter, was removed manually at a six-place picking table. The speed of the conveyor belt of the table was controlled by a variable-speed drive, which permitted operation at slower rates as needed and hence efficient removal of objectionable material. Results obtained from these operations are shown in Table 3.

TABLE 3

Results of blanching and manual sorting of peanuts

No.	Materials separated during blanching			Materials from manual sorting of the cotyledons	
	Germs	Skins	Cotyledons	Accepted*	Rejected
	lbs. per 100 lbs.	*lbs. per 100 lbs.*	*lbs. per 100 lbs.*	*lbs.*	*lbs.*
1	2.1	4.1	93.8	91.6	2.2
2	2.1	4.0	93.9	90.9	3.0
3	2.5	4.3	93.2	91.3	1.9
4	1.9	3.5	94.6	92.8	1.8
5	1.9	4.1	94.0	92.1	1.9
6	1.6	3.9	94.5	92.8	1.7
7	2.4	4.2	93.4	91.3	2.1
8	2.1	3.7	94.2	91.1	3.1
9	2.1	3.9	94.0	91.4	2.6
10	2.2	4.0	93.8	92.4	1.4
11	1.6	4.1	94.3	91.6	2.7
12	2.1	4.2	93.7	91.6	2.1
13	2.8	4.0	93.2	92.0	1.2
14	2.1	4.0	93.9	91.6	2.3
15	1.5	4.1	94.4	91.9	2.5
16	2.0	4.3	93.7	92.1	1.6
17	2.7	4.4	92.9	90.7	2.2
18	2.0	4.0	94.0	91.4	2.6
19	2.8	3.6	93.6	92.8	0.8
20	2.3	4.0	93.7	92.1	1.6

* Used for production of peanut butter.

RESULTS AND DISCUSSION

The results of the roasting investigation indicate that the rate of roasting for the equipment referred to above is constant. The time of roasting for a given weight of peanuts appears to be the most important variable affecting the color of the roasted product, although the temperature to which the roaster was preheated prior to the introduction of the peanuts influences the time required to obtain the desired endproduct. In general, the moisture contents of the peanuts after roasting and cooling are proportionately lower as the darkness of the color of the roasted product increases.

Data obtained during the cooling, blanching, and manual sorting operations indicate that uniformly efficient blanching of peanuts for practical purposes is independent of the degree of roasting. However, the manual sorting of peanuts roasted at higher temperatures or for longer periods of time makes the detection and elimination of unblanched material more difficult because of the lack of contrast between the blanched and unblanched peanuts.

The data shown in Table 3 are indicative of those which may be expected as a result of the split-nut blanching operation.

The amounts of objectionable materials (Table 3) removed during very careful, manual sorting of the blanched peanuts are representative of those present in blanched stocks normally produced in the manufacture of peanut butter.

SUMMARY

Data obtained in an investigation of roasting, cooling, blanching, and manual sorting of twenty batches of white, Spanish peanuts prior to the production of peanut butter have been presented and discussed. Times and temperatures required for roasting peanuts from very light to very dark colors have been determined. The colors of the roasted products have been described in terms of Maerz and Paul's color panels. Moisture contents of peanuts before and after roasting have been reported for each of these products.

It has been determined that, all other conditions being equal, the time of roasting is the most important factor affecting the character of the end product.

Within the range of conditions investigated, the percentage of skins removed is approximately the same regardless of the length of time and temperature of roasting. It has also been determined that a small but appreciable percentage (1-3%) of unblanched and/or discolored and foreign material remains with the peanuts after the blanching operation which should be removed by a supplemental sorting operation prior to grinding into peanut butter.

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Some Factors Affecting Stability of Chicken Fat[a]

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Some factors determining the stability of chicken fat were investigated. The effect of tocopherols (vitamin E) depended on the proportions used.

Oxidative rancidity of the fat is a major factor in the loss of flavor in poultry, which has been refrigerated. Previous experiments have undertaken to determine the effect of pro-and anti-oxidants on fats isolated from the carcass. Other experiments have been directed to determine the influence of various dietary ingredients on the relative stability of the body fats.

Lips *(7)* stated that progressive deterioration follows changes in peroxide values. He noted that moisture or excessive amounts of tocopherols (vitamin E) actually increased oxidation (rancidity) of the fat. In contrast to this, dehydration or 0.05% Vitamin E retarded oxidative changes. Chang and Watts *(1)* reported that stability of thin films of lard was decreased in the presence of solutions of sodium chloride and calcium chloride. As the concentration of the salt solution increased, peroxide values of the fat (rancidity) also increased.

Hanson, Barnes, Lundberg, and Burr *(2)* were one of the first to show that ingestion of vitamin E increased the stability of deposited fat. Schreiber, Vail, Conrad, and Payne *(8)* noted that loss of flavor in frozen poultry paralleled increases in peroxide content of the fat. With the feeding of unsaturated fat, Kummerow, Vail, Conrad, and Avery *(5)* and Kummerow, Hite, and Kloxin *(6)* showed that the keeping quality of turkeys in cold storage decreased. On a diet high in unsaturated fat, more fat was deposited in the birds and stability decreased. Feeding of ethanolamine or choline decreased the amount of fat deposited. The fat of birds that had been fed choline was most stable. Hite, Kloxin, and Kummerow *(3)* found that more linolenic and arachidonic acid was deposited in turkeys when they were fed a highly unsaturated fat, such as linseed oil. These unsaturated fatty acids decreased stability of the fat. Feeding ethanolamine or choline chloride resulted in less deposition of linolenic and arachidonic acid. The fat from these groups was more stable than that of the unsupplemented groups.

The present paper reports the results of 2 experiments conducted on the effects of moisture, vitamin E, and ammonium chloride on the stability of rendered chicken fat, and of feeding tocopherol, choline chloride, and betaine concentrate on the stability of skin fat.

EXPERIMENTAL

In the experiment dealing with the effects of moisture, vitamin E, and ammonium chloride on the stability of rendered chicken fat, 5 New Hampshire hens that had been fed a conventional laying ration were used as a source of fat. After killing, scalding at 140° F. (60° C.) and picking, they were chilled overnight in a refrigerator at 35° F. (1.5° C.). The fat was isolated from the visceral cavity. Care was taken to avoid contamination. All fat samples were combined and rendered over a water bath at 212° F. (100° C.). This was done under nitrogen in order to decrease oxidation of the fat at elevated temperature. Two reasons for rendering the fat were to destroy any enzyme that may have been present, and to get the fat in a form that could be more accurately measured.

Lips *(7)* and Chang and Watts *(1)* have shown that moisture surrounding the fat increases oxidation or rancidity. The possibility exists that tissue moisture contains substances which inhibit or accelerate fat oxidation. The addition of distilled water to a fat sample to be tested for the onset of rancidity ignores this possibility. For this reason, a water-fat extract was added to most of the fat samples.

The extract was prepared by homogenizing 1 g. of rendered fat in 10 ml. of water for 3 minutes in a Waring Blendor. The homogenate was then filtered and the filtrate was used as the water-fat extract.

Rendered fat (10 ml.) was pipetted into 250 ml. Erlenmeyer flasks and then weighed. Supplements, as indicated in Table 1, were added to the fat. The samples were mixed by gentle rotation, and stored in a constant temperature oven at 102° F. (39° C.) for 92 hours. After this time, the fat was separated from the aqueous phase by extraction in a separatory funnel with 20 ml. of chloroform. Peroxide values were then determined by Wheeler's iodometric peroxide method *(9)*.

TABLE 1

Peroxide values of rendered chicken fat in the presence of various materials[b]

Sample	Supplement	Water	Water-fat extract	Peroxide value of fat
	Mg. per g. fat	*ml.*	*ml.*	*m.e.q. per g.*
1	None	....	....	0.53
2	None	20	....	3.81
3	None	....	20	1.31
	Tocopherol acetate			
4	0.012	....	20	1.29
5	0.029	....	20	1.12
6	0.062	....	20	1.05
7	0.127	....	20	1.02
8	0.143	....	20	0.87
9	0.290	....	20	0.80
10	0.634	....	20	0.92
11	1.430	....	20	0.93
12	2.560	....	20	1.62
13	4.350	....	20	1.17
14	14.500	....	20	1.13
	Ammonium chloride			
15	5.37	....	20	1.46
16	26.35	....	20	1.55
17	54.15	....	20	1.92
18	115.40	....	20	2.90

[b] These results were confirmed by 4 replications.

In the experiment dealing with the effects of feeding vitamin E, choline chloride, and crude betaine concentrate on the skin fat stability, 48 New Hampshire cockerels, 2 months of age, were divided into 4 groups. A normal base ration, as shown in Table 2, was fed to each group for 15 days. One group was fed a supplement of vitamin E (alpha-tocopherol acetate) with the base ration, a second group was supplemented with choline chloride, and a third group with crude betaine fraction of beet juice. The controls were fed only the base ration. The birds were housed on new corn cob litter. At the end of the experi-

[a] Published with the approval of the Director as Paper No. 551, Journal Series, Nebraska Agricultural Experiment Station.

TABLE 2

Composition of base ration used in Experiment II

Ingredient	%
Yellow cornmeal	34.0
Shorts	20.0
Bran	10.0
Dehydrated alfalfa meal, 17% protein	5.0
Soybean meal	10.0
Corn gluten meal	8.0
Meat scraps	5.0
Supertrate—fish solubles	2.0
Dried buttermilk	2.0
"D" blend (200 A. O. A. C. units per g.)	1.0
Ash mix	3.0
	100.0

mental period, the cockerels were dressed as in Experiment I, and then stored at 0° F. (—18° C.) without wrapping.

After 7 months, the birds were thawed, and the skin removed and combined for each group. Each composite sample was cut into small pieces, and the fat extracted in a Waring Blendor for 1 minute with chloroform. The mixture was filtered and chloroform was added to the extract to restore the initial volume. Peroxide values were determined as in Experiment I.

RESULTS

The results of Experiment I are shown in Table 1. Samples No. 1 to No. 3 demonstrate the effect of moisture on rendered fat. Sample No. 1, which was free of moisture, was least rancid, as indicated by the low peroxide value. In contrast to this, sample No. 2, to which only water was added, was most rancid. The water-fat extract (sample No. 3) contained some substance, or was modified so that it inhibited the onset of rancidity as compared to the sample containing water. The peroxide value of the water-fat extract was determined, and was found to be 0.01 m.e.q. per 20 ml. of extract.

Sample No. 3 was also the control for samples No. 4 to No. 18. The addition of vitamin E (alpha-tocopherol acetate) to samples No. 4 to No. 9 in increasing amounts stabilized the fat up to an optimal concentration of about 0.03% vitamin E. This is indicated by the low peroxide value of sample No. 9. Above this concentration, the addition of vitamin E (samples No. 10 to No. 14) accelerated the oxidation or rancidity of the rendered fat. A concentration of vitamin E of 0.3% appeared to promote rancidity in this case (sample No. 12).

Ammonium chloride (samples No. 15 to No. 18) increased the peroxide values of the fat. All samples to which ammonium chloride was added were more rancid than the control (sample No. 3).

The results of Experiment II are shown in Table 3. There was no appreciable difference between the four groups for the amount of fat deposited in the skin. The mean weight gain, which was approximately 0.4 lb. per week, was relatively consistent for the groups. The skin fat of the choline chloride group was more rancid. Addition of Vitamin E decreased the onset of rancidity in the skin fat. There was no obvious difference in the peroxide values of the controls and the group fed a supplement of crude betaine fraction of beet juice.

TABLE 3

Organization and results of Experiment II. Twelve cockerels used in every experiment.

Supplement, base ration	Fat, skin	Weight increase	Peroxide values
Mg. per 100 g.	*g. per g.*	*lbs. per week*	*m.e. q./g. fat*
220 choline chloride	0.236	0.41	18.30
1915 betaine fraction [a]	0.133	0.45	10.45
None	0.176	0.46	10.41
50 α-tocopherol acetate	0.185	0.45	8.95

[a] International Mineral and Chemical Corporation states that the crude betaine fraction of beet juice contains 11.5% anhydrous betaine.

DISCUSSION

Rendered chicken fat in the presence of excess moisture was less stable than fat that was relatively moisture free. This is in agreement with studies on lard *(7)*. The moisture content of carcass fat might have a definite relationship to its stability. Although this was not the objective of this experiment, it may be related to the problem.

Some material or condition in the water-fat extract, as described, retarded the onset of rancidity, as compared to the sample containing distilled water. Even after filtration, there were some microscopic fat globules in the water-fat extract. These could not be removed by centrifugation, nor by extraction with chloroform. Whether the decreased rancidity was due to a substance or a condition (permanent fat emulsion) is unknown.

Vitamin E functioned as an effective anti-oxidant at a concentration of 0.03%. Probably the breakdown products of the tocopherol when incorporated in excessive amounts was the factor responsible for increased peroxide values.

Ammonium chloride in the concentrations used accelerated oxidative changes in the fat. This may have been the same sort of relationship as shown by Chang and Watts *(1)* in their work with lard and various salts. However, it would be interesting to know if ammonia acts as a pro-oxidant in the autoxidation of chicken fat.

Choline, betaine, or ethanolamine should all have similar action because of their interrelationship *(4)*. Choline and ethanolamine decreased the amount of fat deposited in turkeys fed a diet high in unsaturated fat *(6)*. On a normal ration, as used in Experiment II, this was not found to be the case for skin fat in cockerels. The choline group in this experiment actually deposited just slightly more fat (Table 3) than the other groups and the fat was found to be least stable. The crude betaine fraction of beet juice had no such effect. There was little, if any difference between this group and the controls when fat stability or weight gain was considered. The crude betaine fraction could possibly be substituted for choline for nutritive purposes. However, there appears to be no advantage in feeding excess choline or betaine fractions for increased stability of skin fat in cockerels when the basic ration is similar to the one described.

Feeding vitamin E resulted in the deposition of a more stable skin fat. This appeared to be in agreement with the results of other workers on rendered fat *(7)*, as well as naturally deposited fat *(2)*.

SUMMARY

Two experiments were conducted in an effort to determine some of the factors affecting chicken fat stability. Moisture, ammonium chloride, and excess (0.3%) vitamin E increased rancidity of rendered fat as measured

by peroxide values. An optimal vitamin E concentration (0.03%) and the absence of moisture resulted in a more stable rendered fat.

Feeding choline chloride or crude betaine fractions of beet juice did not increase the stability of skin fat in cockerels when fed with a normal growing ration. Addition of vitamin E to the diet at the level indicated increased the stability of the deposited skin fat.

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Effect of a Drop in Retort Temperature Upon the Lethality of Processes for Convection Heating Products

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The effect of various drops in the retort temperature on the lethality attained in convection-heating products was determined. Based on experiments with 1% bentonite suspensions, corrections are given for various retort temperature drops for cans of three sizes.

A temporary drop in retort temperature during a process occurs occasionally under commercial conditions. This loss of heat is usually compensated for by adding an arbitrary amount of time to the process, but no definite information has been available on the extent of the loss of lethality in a can of food caused by various degrees of drop in retort temperature. The work reported here was undertaken to determine what lethal values are lost in certain common sizes of cans containing convection heating products when the retort temperature drops 2° to 10° F. (1.1° to 5.5° C.) for various lengths of time. The lethal value is the sterilizing value of a process expressed as minutes at 250° F. (121.1° C.), when the slope of the thermal death time curve on semi-log paper *(z)* equals 18° F. (10° C.).

EXPERIMENTAL PROCEDURE

A 1% bentonite suspension was used to simulate a convection-heating product because of its convenience, and additional work was done on actual food products as a check on the data obtained. The bentonite was prepared and heat penetration tests were made according to the procedure outlined by Townsend, Reed, McConnell, Powers, Esselen, Somers, Dwyer, and Ball *(2)*. The 307 x 409, 401 x 411, and the 603 x 700 size cans were used with retort temperatures of 240°, 245°, and 250° F. (115.6°, 118.3°, and 121.1° C.), and temperature drops of 2°, 4°, 6°, 8°, and 10° F. (1.1°, 2.2°, 3.3°, 4.4°, and 5.5° C.).

The cans were allowed to reach retort temperature at their slowest heating spot before the retort temperature was lowered, and the changes in retort temperature were effected as rapidly as possible in order to produce the maximum loss of lethal value. The retort was cooled by opening the over-flow valve. The time required for the retort temperature to drop 2° to 10° F. (1.1° to 5.5° C.) ranged between 0.1 and 1.0 minute, and between 0.1 and 0.6 minute was required for the retort temperature to return to its original level. The loss of lethality, or lethal value, was determined by the general method of Bigelow, Bohart, Richardson, and Ball *(1)*, assuming the cans would have stayed at retort temperature if no temperature drop had occurred. This loss of lethality, divided by the lethal value of one minute at retort temperature, $1/[\log^{-1}(250 - T/18)]$, where "T" represents retort temperature in ° F., gave the loss of lethality in terms of process time at retort temperature.

RESULTS AND DISCUSSION

Comparison of the Loss of Lethality at the Side and Center of a Can

Heat penetration measurements were made in 307 x 409 and 603 x 700 cans of 1% bentonite with thermocouples placed at the slowest heating positions (½-inch and ¾-inch above the bottom of the can on the vertical axis, respectively), and also at the same distance above the bottom but ⅛-inch from the side of the same can. The object was to determine if there was a difference in the loss of lethal value between the slowest heating (or cooling) and the fastest heating positions when a drop in retort temperature occurred.

The results of these tests indicate that in most cases the losses of lethality at the slowest heating position and at a point near the side of the 307 x 409 cans were approximately the same. In 603 x 700 cans the loss of lethality at the slowest heating position was usually slightly less than that found near the side of the can. The slopes of the heat penetration curves obtained at both positions were identical; however, the lag factor

(j value) of the heat penetration curve obtained at the slowest heating position was much greater than that obtained at the position near the can side. The lethal value attained for a given process in which a drop in retort temperature occurred was usually less at the slowest heating position than at a position near the side of the can because of this greater lag in the rate of heat penetration. Typical data obtained on the same bentonite suspension in the two can sizes are shown in Table 1.

TABLE 1

Heating data obtained at the slowest heating positions and at a position near the side of a can containing 1% bentonite suspension

Can size	Slowest heating position [a]		Side position [b]	
	j	f_h	j	f_h
307 x 409	0.58	3.6	0.38	3.6
603 x 700	1.48	6.2	0.92	6.2

[a] ½" to ¼" above bottom of can on vertical axis.
[b] ½" to ¼" above bottom of can and ⅛" from side.

It appears valid to use data for the slowest heating position for calculating the effect of a drop in retort temperature on the lethality of a process for convection heating products.

Loss of Lethality Caused by Different Drops in Retort Temperature

At least 4 cans were used for the heat penetration tests for each combination of variables (can size, retort temperature, number of ° F. drop in retort temperature, and duration of retort temperature drop). From 2 to 6 determinations, involving from 8 to 24 cans, were made for each condition and the data from the cans giving the greatest loss in lethality under each separate condition were tabulated.

The additional processing time necessary to compensate for a drop in retort temperature was found to be practically independent of the value of retort temperature and the size of the can within the limitations of this experimental work. The data which yielded the greatest loss of lethality were used to construct the curves of Figure 1, from which the data of Table 2 were tabulated. The values in this table present the number of minutes which should be added to a process to compensate for the various retort temperature drops at retort temperatures between 240° and 250° F. (115.6° and 121.1° C.). Because the same results were obtained with the 307 x 409 and the 603 x 700 size cans, it is probable that these data can be applied to practically any size can containing products heating by convection.

The correction factors presented in Table 2 are too great in cases where the temperature drop occurs near the beginning and end of the process.

Temperature drop near the beginning of a process. If the temperature drop should occur before the coldest spot in the can has reached retort temperature, the loss of lethal value would be less than if the retort temperature had been reached in the can, the conditions under which the correction factors in Table 2 were determined. If the temperature drop occurs within 5 minutes after the beginning of the process, these corrections will

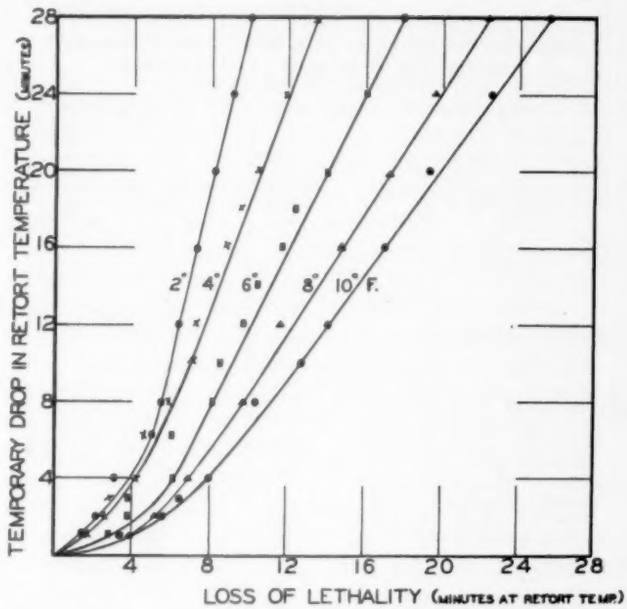

Figure 1. Loss of lethality caused by temporary drops in retort temperature. Results obtained with 307x409, 401x411, and 603x700 size cans and at 240°, 245°, and 250° F. (115.6°, 118.3°, and 121.1° C.) retort temperatures.

TABLE 2

Time to be added to a process for convection-heating products to compensate for a drop in retort temperature. Determined on 1% bentonite suspension in 307x409, 401x411, and 603x700 cans. Retort temperature: 240° F., 245° F., and 250° F.

Duration of temperature drop	Temperature drop				
	2° F.	4° F.	6° F.	8° F.	10° F.
	Minutes [c] to be added to the process				
Minutes					
1	2[d]	2[d]	3[d]	5[d]	5[d]
2	3[d]	3[d]	5[d]	6[d]	6[d]
3	4[d]	4[d]	6[d]	7[d]	8[d]
4	4	5[d]	7[d]	8[d]	8[d]
5	5	5	7[d]	8[d]	9[d]
6	5	6	8[d]	9[d]	10[d]
7	6	6	8[d]	10[d]	11[d]
8	6	7	9[d]	10[d]	12[d]
9	6	7	9	11[d]	12[d]
10	6	7	10	12[d]	13[d]
11	7	8	10	12[d]	14[d]
12	7	8	11	13[d]	15[d]
13	7	9	11	14[d]	15[d]
14	7	9	12	14	16[d]
15	8	9	12	15	17[d]
16	8	10	13	15	18[d]
17	8	10	13	16	18[d]
18	8	10	14	17	19[d]
19	8	11	14	17	20[d]
20	9	11	15	18	20
21	9	11	15	19	21
22	9	12	16	19	22
23	9	12	16	20	23
24	10	13	16	20	23
25	10	13	17	21	24
26	10	13	17	22	25
27	10	14	18	22	26
28	10	14	19	23	26

[c] Fractional minutes rounded to next higher minute.

[d] If the retort temperature drops at very end of a process, the correction should be the length of the retort temperature drop. If the temperature drop occurs near the beginning of process use following procedure: If corrected process results in a number of minutes after the end of the temperature drop greater than the original process, use the regular process, taking the start of the process as the time when the retort reaches retort temperature after the temperature drop.

TABLE 3

Comparison of the effect of a drop in retort temperature on the loss of lethality in food products and in 1% bentonite

Product	Can size	Retort temperature	Retort temperature drop		Loss of lethal value (in terms of process time at retort temperature)	
					Product	1% Bentonite
		°F.	°F.	Min.	Min.	Min.
Asparagus tips, processed						
Tips down	307 x 409	240	2	3	0.8	3.1
Tips up	"	"	2	3	0.3	3.1
Tips down	"	"	6	3	3.1	5.4
Tips up	"	"	6	3	3.1	5.4
Tips down	"	"	8	4	5.5	7.1
Tips up	"	"	8	4	5.5	7.1
Tips down	"	"	10	4	5.4	8.0
Asparagus cuts, processed	307 x 409	240	10	6	10.0	9.7
Asparagus cuts, fresh	401 x 411	245	6	2.5	4.1	4.9
Same	"	"	6	3.5	5.0	5.9
Same	"	"	6	5	5.8	6.7
Same	"	"	6	8	7.4	8.2
Same	"	"	6	12	9.5	10.2
Same	"	"	6	16	11.7	12.2
Same	"	"	6	20	13.8	14.2
Same	"	"	6	24	16.0	16.2
Same	"	"	6	28	18.1	18.1
Asparagus cuts, fresh	603 x 700	245	6	11	7.1	9.7
Same	"	"	6	13	7.9	10.7
Same	"	"	6	16	9.4	12.2
Beans, cut green, processed	307 x 409	240	4	9	4.0	6.7
Beans, cut green, processed	401 x 411	240	2	4.5	1.6	4.2
Beans, cut green, fresh	"	"	2	4.5	3.5	4.2
Beans, cut green, processed	"	"	4	5.5	4.5	5.0
Same	"	"	6	4.5	5.3	6.5
Same	"	"	8	5.5	5.0	8.3
Beans, cut green, fresh	"	"	8	5.5	8.6	8.3
Beans, cut green, processed	"	"	8	6.5	6.1	9.0
Same	"	"	10	5.5	6.2	9.3
Beans, cut green, fresh	"	"	10	5.5	9.5	9.3
Beans, mature in brine	603 x 700	240	6	12	5.3	10.2
Carrots, sliced, processed	307 x 409	240	2	3	0.8	3.1
Same	"	"	4	5	3.2	4.7
Carrots, sliced, fresh	"	"	4	5	3.7	4.7
Carrots, sliced, processed	"	"	4	9	6.2	6.7
Same	"	"	8	4	6.3	7.1
Same	"	"	10	6	8.2	9.7
Carrots, sliced, fresh	"	"	10	6	7.4	9.7
Carrots, sliced, processed	"	"	10	10	9.7	12.7
Carrots, sliced, fresh	"	"	10	10	9.1	12.7
Carrots, whole, fresh	603 x 700	245	6	3	2.1	5.4
Same	"	"	6	7	4.3	7.7
Carrots, diced, fresh	603 x 700	240	4	7	4.0	5.8
Same	"	"	4	12	5.9	7.8
Same	"	"	4	15	7.2	8.9
Olives, ripe, processed	307 x 409	240	2	4	1.2	3.9
Same	"	"	4	5	2.9	4.7
Same	"	"	6	5	3.9	6.7
Same	"	"	8	6	5.1	8.6
Same	"	"	10	1	1.3	4.1
Same	"	"	10	4	4.0	8.0
Olives, ripe, processed	603 x 700	240	8	3.5	4.5	6.7
Same	"	"	8	5	5.2	7.8
Same	"	"	8	8	6.6	9.9
Olives, ripe, processed	603 x 700	240	10	10	8.2	12.7
Same	"	"	10	15	10.5	16.3
Peas, processed	307 x 409	240	4	5	4.0	4.7
Same	"	"	4	9	6.9	6.7
Same	"	"	6	3	5.2	5.5
Same	"	"	10	4	7.6	8.0
Same	"	"	10	6	8.4	9.7
Same	"	"	10	10	11.3	12.7

sometimes result in a process time, after the temperature drop, greater than the original process time. This occurs when the correction is greater than the process time before the start of the temperature drop plus the time of the temperature drop. Under these conditions it is recommended that the original process be used after the retort temperature drop, rather than the corrected process.

Temperature drop near the end of a process. If the end of the process occurs before the cold spot in the can has reached retort temperature again after a temperature drop, the loss of lethality would be less than if the can temperature had again reached retort temperature before the process ends. Therefore all the correction factors in Table 2 are too great under these conditions. To reduce this error somewhat, it is suggested that the length of temperature drop be used as the correction when the temperature drop occurs at the end of the process and the corrections in Table 2 are greater than the length of the temperature drop.

Comparison of the Loss of Lethality in Canned Foods and One Percent Bentonite Suspensions Caused by Retort Temperature Drops

The effect of retort temperature drops on the loss of lethality in several food products was determined by the method described above and the results compared to those obtained on 1% bentonite. These results are reported in Table 3 and are the slowest data obtained on at least three cans. The 1% bentonite data were obtained from Figure 2.

The loss of lethality obtained with 1% bentonite was approximately as great or greater than the loss obtained with food products exposed to the same retort temperature drop. These data provide a considerable safety factor in favor of the the 1% bentonite data, especially when the data are rounded off to the next higher minute as was done in Table 2.

SUMMARY

The effect of various drops in retort temperature on the lethality attained in convection heating products was determined. Corrections for 307 x 409, 401 x 411 and 603 x 700 cans for various retort temperature drops, based mainly on results obtained with 1% bentonite, are presented. These corrections provide a safety factor when compared with those obtained on several food products.

These data should be applicable to convection-heating products such as asparagus spears; asparagus cuts in 401 x 411 cans and smaller cans; whole or cut green beans; mature beans, and soaked shelled dried legumes in brine; bean sprouts; carrots; cauliflower; hominy; olives; peas, and other products heating by convection.

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Book Review

THE PECTIC SUBSTANCES. By Z. I. Kertesz. 628 pages, 74 tables and 46 figures. Interscience Publishers, Inc., New York, N. Y. 1951. Price $13.50.

This volume covers, in five parts: I, Chemistry; II, Botany; III, Biochemistry; IV, Manufacture; and V, Functions and Applications of Pectic Substances.

Part I on Chemistry of Pectic Substances comprises 259 pages and serves to correlate widely scattered bits of information into an organized monograph. Chapter I on Definitions and Nomenclature serves to clarify the confusion which has existed in regard to nomenclature used in various domestic and foreign publications in the past.

The section on Botany discusses the occurrence and role of pectic substances in plants. Under Biochemistry pectic enzymes are discussed as well as the utilization of pectic substances by microorganisms and their behavior in the animal body.

The manufacture of various pectic preparations is discussed in Part IV. In Part V the uses in food and non-food products are discussed, as well as the uses of pectic enzymes for clarification of fruit juices and other purposes.

This is an outstanding contribution in a field never before adequately covered in one volume. Because of the authoritative treatment of separate subjects, this volume should find wide usefulness among a variety of readers from the straight scientific group wishing to know the present concept of the nature of pectin to the practical user of commercial pectin in jams and jellies baffled because his cherry jelly will not set. It is the first effort to cover such a wide field relating to pectin in one volume.

The publication of such an authoritative book is very timely as research in the field in the past decade has cleared up so many of the previous uncertainties. The subject is adequately covered in a clear, logical and impartial presentation with numerous references to original work given in footnotes. The indices, both author and subject, are thorough and add greatly to the usefulness of the volume. The book is printed on good stock with clear type and is cloth bound (16 x 24 cm.). The text is remarkably free of typographical errors.

This worthy monograph should certainly fulfill the author's hope "that it will be helpful in orientation of newcomers to the field and aid those interested in problems related in any manner to the pectic substances."

H. H. MOTTERN.

STÄRKE, STÄRKESIRUP, STÄRKEZUCKER. By W. R. Aehnelt. Technische Fortschrittsberichte, Band 53. Edited by B. Rassow. 306 pages, illustrated. Theodor Steinkopf, Dresden and Leipzig, 1951. Price with paper cover, RM 15.00; bound, RM 17.00.

This volume is one of a series devoted to advances in various industrial fields. Its stated purpose is to present in a concise form technical advances over the past fifteen years. For earlier work frequent reference is made to older and more comprehensive treatises. The book should prove useful to research workers and engineers desiring acquaintance with the field of starch products. A bibliography of 807 references covers the patent and periodical literature including some obscure sources of information. Much credit is due the author for surmounting current difficulties in searching the literature so widely.

The subject material is divided into eleven chapters under the following headings: I. Occurrence of starch, II. Starch in world economy, III. Manufacture of starch, IV, Characterization, structure and evaluation of starch, V. Uses of starch, VI, By-products of starch manufacture, VII. The degradation of starch, VIII. Methods of degradation of starch—Preparation of commercial products, their characterization and applications, IX. Starch syrup, X. Starch sugar (dextrose), XI. Compounds and derivatives of starch and dextrose. References are listed at the end of the book together with author and subject indexes. Likely owing to shortages, the quality of paper and binding is inferior but better paper has been used for those pages containing photographs or detailed drawings.

Topics are illustrated by process flow sheets, diagrams and photographs. Selected data from original sources are tabulated to support the text. In this respect the author appears to be quite thorough.

The book should be read with caution for there are many errors of interpretation of published work. Furthermore, much space is allotted to subject matter which is interesting but of minor importance whereas more important work is overlooked. For example, preparation of starch from quite unusual sources is described in detail while mention of the waxy maize and sorghum breeds is omitted altogether. Likewise, zein, an important industrial product of recent years, is given only the briefest mention. However, in this book one might logically expect more emphasis on European raw material sources and technology, and in this sense the book fulfills its purpose more than may be apparent to the American worker.

A brief section describes fundamental work on the structure of starch. Unfortunately much recent work has been overlooked. Reference to this work, at least, would help bring the reader up to date and give him a better understanding of the relationship between structure of starch and its properties and applications. On the other hand, recent advances in manufacture of dextrose by continuous hydrolysis of starch and purification with ion-exchange resins are well described.

The book is quite free of typographical errors. Occasionally an author's name is misspelled, particularly in the bibliography and indexes.

Since very few modern books on the chemistry and industry of starch are available, this volume should be a useful addition to one's library.

GEORGE R. DEAN.

DISTILLATION. Volume IV in TECHNIQUE OF ORGANIC CHEMISTRY. Arnold Weissberger, Editor; eight contributing authors. 668 pages. Interscience Publishers, Inc., New York, N. Y. 1951. Price $14.00.

This is a well organized and clearly presented text on laboratory batch distillation, liberally illustrated with curves and data tables.

The first quarter of the book is devoted to distillation theory, covering vapor liquid composition relations; determination of theoretical plates by the methods of McCabe and Thiele, Fenske, Sorel, Lewis, Smoker, etc., and differential equations of performance descriptive of concepts other than that of theoretical plates which have been used in the attempt to gain a clearer picture of the fractionating process. A section is included evaluating calculated effect of process variables in batch distillation.

The chief value of the book, however, lies in the experience and "know-how" passed along by the authors of subsequent chapters, in which a comprehensive account is given of laboratory scale distillation at ordinary and reduced pressures with emphasis on equipment, construction and operation, and evaluation of results. Many types of columns and column packings are described and illustrated and fractionating efficiencies are discussed and compared in the text and in the numerous graphs and tables. The scope of the subject material can be best illustrated by listing the chapters and authors.

Theory, by Arthur and Elizabeth Rose,
Ordinary Fractional Distillation, by A. L. Glasebrook and F. E. Williams,
Extractive and Azeotropic Distillation, by Carl S. Carlson,
Distillation of Liquefied Gases and Low-Boiling Liquids, by Arthur and Elizabeth Rose,
Distillation Under Moderate Vacuum, by John R. Bowman and R. Stuart Tipson,
Distillation Under High Vacuum, by E. S. Perry and J. C. Hecker, and
Sublimation, by R. Stuart Tipson.

Scientists concerned with organic research or quality control will want copies of this text on their own bookshelves; those concerned with chemical engineering pilot-plant studies will want it readily accessible.

JAMES CORDING, JR.

MEAT TECHNOLOGY. By Frank Gerrard. 309 pages. Leonard Hill Ltd., London. Second edition, 1951. Price 15 shillings, 10 pence.

This is the second edition of a book first published in 1945. Written in England by the Acting-Principal, Smithfield College of Food Technology, treatment of the subject largely from the British point of view as is readily understood.

The author has devoted major attention to cattle and beef. Following a brief discussion of the evolution of cattle, he deals with the skeleton, organs and lymphatic system and presents a nomenclature for male and female bovines as commonly applied throughout Great Britain and the British Commonwealth. Live cattle are considered with respect to growth, types coming to market, effect of fattening on carcass composition, variation in local preferences, inspection for healthfulness, "quality points," "handling points," and indications of age. Descriptions of the characteristics of a number of British beef and dual-purpose breeds is presented at some length.

Cattle slaughtering procedures, including the handling of by-products, and dressing percentages are dealt with in considerable detail. The characteristics of bone, ligaments and tendons, fat, and muscle are discussed in relation to carcass quality; bull, cow, ox and heifer beef are described. The chapters on cattle are concluded with descriptions for grades of carcasses of home-killed bullocks and heifers and veal calves. Sheep and mutton, pigs and pork, and poultry are discussed similarly although not so fully as cattle and beef. Even rabbits receive brief mention.

Preservation of meat in relation to temperature, absence or reduction of moisture, and chemical preservatives and to the commercial application of those factors is presented briefly. Similar treatment is accorded postmortem changes in meat, including conditioning,—generally termed "ripening" in the United States.

Cutting techniques for beef, lamb and mutton, pork, veal, and Wiltshire bacon are a topic of major consideration. Results of a number of cutting yield tests are included.

There is a brief discussion of meats in relation to nutritional properties and to demands in Great Britain. The text concludes with some attention given to the distribution of food animals throughout the world and in England and Wales.

The book is judiciously supplied with illustrative, graphic, and tabular material, although it is probable that many readers would be helped by a more complete bibliography. The index is excellent.

The volume is of convenient size, the printing is good and, excepting a few of the photographic reproductions, the figures are clear. Although not of great interest to researchers, this book should prove very useful to students of meat technology and to many workers in the meat industry, especially in Great Britain.

O. G. HANKINS.

INTRODUCTORY CHEMISTRY. By Lillian H. Meyer. 532 pages. The Macmillan Company, New York, N. Y. 1951. Price $5.00.

This textbook is intended for college freshmen, particularly students of home economics, who may have an opportunity for only one year of chemistry. An adequate basic knowledge of chemistry is presented in simple terms and in an informal manner. Many diagrams and photographs are used to illustrate basic chemical principles and the illustrations are of commonplace happenings in the average home and kitchen. This book, because of its clarity and readily understood illustrations, can be used profitably by the non-chemist in the food industry to gain a working knowledge of the fundamentals of chemistry.

The author has designed the book to conform with her own obviously well planned course in chemistry for home economics students and the first half of the book coincides with the first semester of school. The subject matter included is the basic knowledge of atoms and molecules, chemical compounds, and chemical reactions. The second half of the book, coinciding with the second semester of school, covers fundamental concepts of organic chemistry, biochemistry (human metabolism), and textile chemistry.

W. A. MACLINN.

Sweetening Agents for Canned Peaches

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(Manuscript received December 10, 1951)

The effect on palatability of using corn sirup or honey to replace all or part of the sucrose in canned peaches or of canning peaches with no added sweetening agent was studied.

Although sucrose has been widely used in canning, there has been considerable interest in other sweeteners and in canning fruit without added sweetening for use in baking and in special diets.

Various amounts of such sweetening agents as corn sirup and honey have been recommended for home canning of fruits, but experimental data to support these recommendations have been meager. Some problems may be expected since corn sirups generally are somewhat less sweet than sucrose, and honey changes flavor at high temperatures because of evaporation of essential oils and caramelization of the sugars *(2)*.

The Bureau of Human Nutrition and Home Economics, using peaches because they are a commonly canned fruit, studied the effect on palatability of replacing ⅓, ½, ¾, and all of the sucrose with light corn sirup and ⅓, ½, and ⅔ of the sucrose with honey of medium color and fairly mild flavor. A total of ½ cup sweetening agent was used per quart of canned fruit. In addition, unsweetened packs were made by precooking peaches in a small amount of water, extracted peach juice, or in their own juice released during heating. To prepare extracted juice, peaches were crushed, heated to boiling, and strained. Peaches canned with sucrose were used as a control against which the experimental packs were compared.

EXPERIMENTAL PROCEDURE

Firm, ripe freestone peaches were prepared and processed according to Bureau directions for hot packing juicy fruit, adding the sucrose directly to the fruit *(1)*. After storage at room temperature for 3, 6, 9, and 12 months, the canned peaches were rated by six experienced judges on appearance, texture, flavor, and general acceptability. Unsweetened packs were scored both "as canned" and after sweetening as follows: The juice was drained from each quart jar, ¼ cup sucrose was added to the juice which was heated to boiling then poured over the fruit and allowed to stand 5 hours before serving.

Peaches from two jars of each pack were rated at the end of each storage period. Ratings were limited to scores of 3, 2, and 1: 3 indicated the best quality; and 1, an unacceptable product. Variance analyses of scores were made to aid in evaluating results.

RESULTS

Light corn sirup can replace as much as ¾ of the sucrose in canned peaches without changing their eating quality, since scores for peaches canned with sucrose and those with ⅓, ½, and ¾ of the sucrose replaced by light corn sirup were similar for all palatability factors studied (Table 1). When all of the sucrose was replaced by the corn sirup, however, flavor scores were significantly lower than for the sucrose pack; scores for texture, appearance, and general acceptability were not affected to any appreciable extent.

When honey of medium color and fairly mild flavor replaced ⅓, ½, or ⅔ of the sucrose, the scores for canned peaches on all palatability factors studied were significantly lower than those for the sucrose pack. Differences in texture, though statistically significant, were of doubtful practical importance. Peaches canned with honey also were scored lower than those canned with corn sirup in any amount, especially on flavor and general acceptability. Palatability scores tended to decrease as the amount of honey used increased. These results apply only to the particular sample of honey used for this experiment; somewhat different results might be expected with milder or stronger flavored honey.

TABLE 1

Mean palatability scores for peaches canned with various sweetening agents or without added sweetening

Precooking and packing medium	Mean score [b]			
	Flavor	Texture	Appearance	General acceptability
All sucrose	2.6	2.4	2.5	2.6
⅓ corn sirup, ⅔ sucrose	2.5	2.3	2.5	2.4
½ corn sirup, ½ sucrose	2.5	2.3	2.5	2.4
¾ corn sirup, ¼ sucrose	2.6	2.4	2.6	2.6
All corn sirup	2.0	2.6	2.5	2.3
⅓ honey, ⅔ sucrose	1.4	2.2	2.3	1.6
½ honey, ½ sucrose	1.2	2.2	2.2	1.4
⅔ honey, ⅓ sucrose	1.1	2.0	1.8	1.1
Extracted juice	1.6	2.0	2.1	1.9
Extracted juice, sweetened before serving	2.4	1.9	2.4	2.2
Water	2.0	2.1	2.4	2.1
Water, sweetened before serving	2.4	2.2	2.2	2.4
Peach juice	1.5	2.3	2.5	1.8
Peach juice, sweetened before serving	2.4	2.5	2.5	2.3

[b] Based on scores for 6 judges, 2 replications, and 4 storage periods; 3 was the highest possible score, and 1 the lowest.

Unsweetened canned peaches prepared with extracted peach juice, water, or their own juice were scored significantly lower on flavor and general acceptability than those canned with sucrose. The main objection to the unsweetened packs was their sour flavor. Peaches canned with water had better flavor than the other unsweetened packs. Peaches canned with extracted juice were scored significantly lower on texture and appearance than those canned with water or their own juice released during heating or peaches canned using sucrose.

[a] Formerly with the Bureau.

Adding sucrose to the unsweetened packs before serving improved the flavor and general acceptability of the canned peaches, but had no effect on texture. Differences in appearance scores were significant only when the pack made with extracted juice was sweetened before serving. Although sweetening before serving improved the eating quality of the unsweetened packs, flavor was not as good as that of the sucrose pack. Any differences in texture, appearance, and general acceptability between the unsweetened packs sweetened before serving and the sucrose pack were not of practical importance.

Data on the effect of storage are not presented in this report since storage differences were significant for only one palatability factor and for only one experimental pack. Peaches canned with honey darkened in color with storage, and were scored significantly lower after 12 months of storage.

SUMMARY

Varying the kind and amount of sweetening agent made considerable difference in flavor and general acceptability of home canned peaches and affected the texture and appearance in some cases. It was found that light corn sirup could replace sucrose in home canning of peaches in amounts up to ¾ of the sweetening agent used, that the honey used in this study imparted a characteristic flavor, and that peaches canned without added sweetening had better flavor when canned with a small amount of water than when canned in extracted juice or their own juice released during preheating. When sweetened before serving, there were no flavor differences in unsweetened packs. In general there were no pronounced changes in palatability when canned peaches were stored for one year.

Acknowledgments

The authors wish to express their appreciation to Elsie F. Dochterman and Albert B. Parks, statisticians in the Food and Nutrition Division, Bureau of Human Nutrition and Home Economics, who assisted in the analysis and interpretation of the data.

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Behavior of the Anthocyanin Pigments in Concord Grapes During Heat Processing and Storage[a]

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(Manuscript received August 18, 1951)

The anthocyanin pigment concentrations of grape juice samples obtained on processing Concord grapes in glass jars at temperatures of 170° F., 210° F. and 250° F. for process times varying from 5 to 100 minutes were determined after storage of the samples for 0, 2, 4, and 6 months at 70 ± 0.5° F. The treatments during storage included the presence of air or nitrogen in the headspace of the container, or storage of the juice samples in the dark or exposed to light when the samples were preserved by pasteurization or addition of toluene. The period of storage exerted the maximum influence on the deterioration of the pigment. Both the mono- and the diglucosides of the anthocyanidin decreased on storage. Decrease in the pigment concentration on processing and storage was more striking in the case of anthocyanin chloride solutions than in grape juice samples.

Grape juice is one of the most popular fruit beverages and its production in the U. S. during 1949-50 was about 2.8 million cases. The color of the clear fruit juice is ranked as an important factor for judging quality. The intense color of Concord grape juice has been attributed principally to the presence of the water-soluble anthocyanin pigments, modified to some extent by the other components of the juice.

Considerable work has been reported on the variation in the color content of grape juice with different processing methods and storage. Hartmann and Tolman *(4)* pointed out that for *Vitis labrusca* varieties a temperature of 150° F. (65.5° C.) should not be exceeded during the heating process as an excessive amount of tannin is extracted from the seeds at high temperatures. Using the grapes of Petite Sirah (a *V. vinifera* variety of red grapes grown in California), Joslyn, Farley and Reed *(5)* observed that the color obtained by heating for 5 minutes at 158° F. matched with that obtained for 18 minutes at 140° F. (60° C.), about 40 minutes at 122° F. (50° C.), 60 minutes at 104° F. (40° C.), and about 2 minutes at 170° F. (76.5° C.). Amerine and DeMattei *(1)* studied the effect of respiration, various gas treatments, and heat on the rate of extraction of the color from uncrushed carignane grapes. No conclusive results on the color extraction were noted due to storage under gas using oxygen, nitrogen, ethylene, and carbon dioxide prior to processing. The best results for color extraction were obtained by dipping the whole grapes in hot water at 203° to 208° F. (95° to 97.5° C.) from 1 to 3 minutes before crushing and processing. Tischer *(10)* described a high temperature process for

[a] Work on this project was made possible through a grant from the Council Bluffs Grape Growers Association, Council Bluffs, Iowa.

[b] Journal Paper No. J-2001 of the Iowa Agricultural Experiment Station, Ames, Iowa Project No. 1051.

the extraction of Concord grape juice in the absence of air using a steam retort. It was reported that no serious losses in juice quality were indicated in the different juices as evidenced by chemical analyses and triangular difference palatability tests.

In studying the visual color changes occurring in Concord grape juice during storage, Tressler and Pederson *(11)* observed that these changes could be reduced by eliminating air from the bottle and further noted that light had a detrimental effect. Pederson and Tressler *(7)* noted that on storage the color of the grape juice changed from reddish purple to a brick red and then to a dull brown simultaneously with clouding and sedimentation. Powers and Esselen *(8)* stated that the effect of light was only of minor importance in the deterioration of glass packed foods in comparison with the deteriorative changes caused by heat and oxygen. Nebesky, Esselen, McConnell and Fellers *(6)*, studying the effects of various factors on the stability of the color in a variety of fruit juices during storage, observed that cherry, grape, and tomato juices were much more stable and exhibited less color deterioration than strawberry, raspberry, and currant juices. Working with purified pigment solutions from strawberries and currants, they observed that high storage temperatures and the presence of oxygen accelerated color deterioration with both pigments, while a low storage temperature preserved the color.

The present study was made to determine the effects of various factors on the stability of the colored components in grape juice prepared from grapes processed for different lengths of times and at different temperatures. The behavior of the principal color components of grape juice on storage under controlled experimental conditions was also investigated.

EXPERIMENTAL PROCEDURE

A cylindrical retort, the temperature of which was accurately regulated, was used for processing. A multi-point, strip-chart, potentiometer type temperature recorder recorded the temperatures inside and outside the containers during the process. Molded plastic, copper-constantan thermocouples, of 2-inch length, were employed as the sensing elements.

Fresh ripe grapes were harvested in the morning from the horticultural farm at Iowa State College, and were processed within a period of 24 hours. Preliminary processing studies indicated that in general, increased color concentrations were obtained with high process temperatures and long process times. The main experimental design was based on these preliminary studies. The process times were chosen such that their logarithmic values were approximately in an arithmetic progression, and the process temperatures were likewise fixed on the assumption that the effect of process times was logarithmically related to process temperatures. Process temperatures of 170° F. (76.5° C.), 210° F. (99° C.), and 250° F. (121° C.) were employed for process times ranging between 5 and 100 minutes.

The order in which the processes were conducted was randomly chosen to minimize experimental errors arising from the temporary storage of the raw product at room temperature before processing. Further, 3 separate replications of each of the processes were done using crushed grapes filled into glass jars of 1 pint capacity. Processing was done by immersing the glass jars completely in water in the retort. The juice samples were collected by centrifuging the cooked mass in a basket centrifuge for 10 minutes at 1500 r.p.m. with cheese cloth serving as a filter. The juice samples were filled into 8 test tubes leaving a headspace of about 1 inch. Toluene was added to 4 test tubes in each sample to prevent fermentation. The remaining 4 test tubes in each sample were pasteurized at 180° F. (82° C.) for 1 minute. In each of the 2 groups of 4 tubes, nitrogen was filled into the headspace of 2 of the pasteurized samples and 2 of the toluene treated samples. In the resulting 4 groups of 2 tubes each treated alike, 1 tube in each group was exposed to light and the other was left in the dark at a constant temperature of 70° ± 0.5° F. (21° C.).

Use of this split-plot factorial arrangement made it possible to have three paired treatment comparisons in each set of tubes as shown in Table 1.

TABLE 1

Split-plot arrangement of three treatments for eight-tube samples of processed Concord grape juice

Tube no.	Paired treatment comparisons		
	Pasteurization (P) vs. toluene (T)	Nitrogen (N) vs. air (A)	Light (L) vs. dark (D)
1	P	N	L
2	P	N	D
3	P	A	L
4	P	A	D
5	T	N	L
6	T	N	D
7	T	A	L
8	T	A	D

Processing at 210° F. (99° C.) and 250° F. (121° C.), and storage studies on the pigment concentrations in the juice samples were also conducted with grapes stored in the refrigerator at 40° F. (4.5° C.) for 1 month. Processing and storage studies on the pigment concentrations were also conducted with clear pigment solutions dissolved in McIlvaine's buffer solution of pH 3.4 (contained in glass jars).

The investigation also included a study of the behavior of the purified anthocyanin pigment on processing and storage. For this purpose the pigment solution was prepared by dissolving 4.25 g. of the anthocyanin pigment, isolated as the chloride from Concord grapes by the method suggested by Anderson *(2)*, in 2 liters of McIlvaine's buffer solution of pH 3.4. Equal volumes of 25 ml. of the pigment solution were processed in glass jars for times and temperatures identical with those used for processing the grapes. The concentrations of the clear pigment solutions before and after the storage periods of 2 and 4 months were determined after diluting 1 ml. of the clear solution to 50 ml. with 2% HCl.

For work involving paper chromatography, Whatman No. 4 filter papers (strips 22.5″ length, 0.75″ width) were used. Initially the solvent used for separation was allowed to flow to the top of the paper strips by capillary action. This procedure facilitated the removal of some yellow colored impurities present in the paper. As these impurities moved along with the solvent front, the ends of the strips containing the colored impurities were cut off. As suggested by Bate-Smith *(3)* the upper layer of the butanol, acetic acid, and water mixture (4:1:5 by volume) was used as the partitioning solvent. Resolution was affected by ascending chromatography using a few drops of the acidified grape juice sample, the number of drops depending on the pigment concentration of the juice sample. Three consecutive runs were made on each sample, each of 4 hours' duration at a temperature of 70° F. ± 0.5° F., the paper being air dried after each run. This procedure seemed to give a better resolution of the individual bands than when separation was made using a single pass of 24 hours' duration.

The anthocyanin concentrations of the pigment solutions were determined by utilizing the property of the clear pigment solutions of pH 1.0 or less that the optical density observed at a wavelength of 515 mμ, bears a linear relationship to the pigment concentration over a limited range. Interference due to presence of soluble brown pigments formed on storage; the thermal breakdown products; and the grape juice components, such as sugar, pectin, tartaric, malic, and tannic acid, were determined. The optical densities of the clear solutions observed at a wavelength of 515 mμ and at pH 1.0 provided a fair indication of the

amount of anthocyanin pigment in grape juice and in solutions of pure pigment isolated from grapes when the samples were suitably diluted.

RESULTS AND DISCUSSION

The yields of juice obtained from fresh grapes and from grapes stored at 40° F. (4.5° C.) for 1 month are included in Table 2. An examination of the data shows that while there is a progressive increase in the yields with fresh grapes with increasing process times at 170° and 250° F., no such trends are noticeable with processes at 210° F. The data also indicate that with grapes stored at 40° F. for 1 month the yields were higher when the processing was at 250° F., compared to the yields obtained after processing at 210° F. No differences in yields were realized when the time of processing was increased beyond 63 minutes at a process temperature of 250° F.

TABLE 2
Yields of grape juice resulting from processes at 170°, 210°, and 250° F.

Temperature	Time	Average yield
° F.	*minutes*	*%*
170	31.5	53.6
170	39.7	54.9
170	50.0	60.0
170	63.0	60.5
170	79.0	61.8
210	12.5	62.6
210	15.8	65.4
210	20.0	62.3
210	25.0	66.2
210	31.5	61.9
210[c]	31.5	63.8
210[c]	63.0	63.9
210[c]	100.0	67.8
250	5.0	62.5
250	6.3	65.8
250	7.9	62.3
250	10.0	67.7
250	12.5	73.8
250[c]	12.5	68.5
250[c]	31.5	72.7
250[c]	63.0	79.6
250[c]	100.0	79.1

[c] Processes on grapes stored at 40° F. for one month.

The concentrations of pigment in grape juice and in purified pigment solutions resulting from processing at 170°, 210°, and 250° F. are presented in Figure 1 in terms of optical densities. From these data it is evident that the purified pigment solution was partially destroyed during processing. In addition, the rate of destruction was proportional to the time and temperature of the process. The values presented for the optical density of grape juice indicate that when grapes were processed at 170° F. under the conditions imposed in this investigation, no progressive increase in concentration of the color was obtained by increasing the process time from 31.5 minutes to 79 minutes. When the processing was done at 210° F. the color content increased progressively when the process time was increased from 12.5 to 31.5 minutes, while a further increase in process time up to 100 minutes did not bring about an increase in the pigment concentrations of the juice samples. The concentration of pigment in juice samples processed at 250° F. for the relatively short times usually considered necessary at this temperature was similar to that found for the two lower temperatures but exhibited no clear influence of time of processing. For times longer than 63 minutes at 250° F. the pigments were brownish red and the juice was slightly turbid while those processed for times less than 63 minutes were red in color. The juice samples prepared by processing at 170° F. were purple. This difference in color may be due to the presence of the other components present in the juice samples which modify the color due to the anthocyanin pigment. This assumption was made as the pH of the different samples did not vary enough to suggest pH as the cause for differences in color.

The shapes of the absorption curves of the juice samples determined over a range of 400-600 mμ using a Coleman spectrophotometer exhibited maxima at 515 mμ for samples adjusted to pH 1.0 with the exception of the juice samples prepared with process times of more than 63 minutes at 250° F., the optical densities of these juices at 400 mμ were almost equal to those at 515 mμ. Apparently as the anthocyanin pigment was destroyed with increasing process time at 250° F. beyond 63 minutes, the optical densities at 515 mμ were lowered and the degradation products of the anthocyanin possessed higher absorption values around 400 mμ. Other changes such as a Maillard reaction, deterioration of pectic substances or of ascorbic acid may also have caused the maxima to shift.

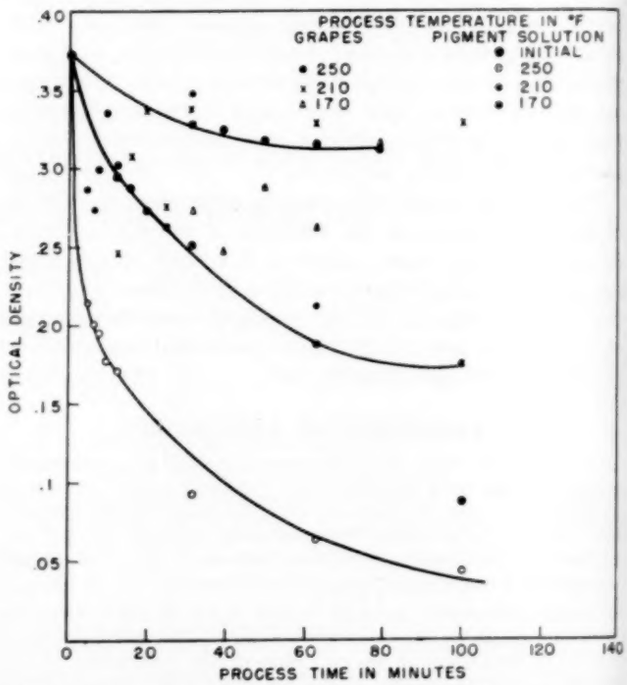

Figure 1. Variation of pigment concentrations of grape juice samples and pigment solutions immediately after processing, with process times. Pigment concentrations are expressed as average values of optical densities at 515 mμ at pH 1.0 of solutions (1:100, 1:50) of juice samples and pigment respectively.

The concentration of pigments in the grape juice samples resulting from storage for 0, 2, 4, and 6 months are presented in Figures 2 and 3. The results indicate that the pigment concentrations were higher in every case when nitrogen formed the headspace and the sam-

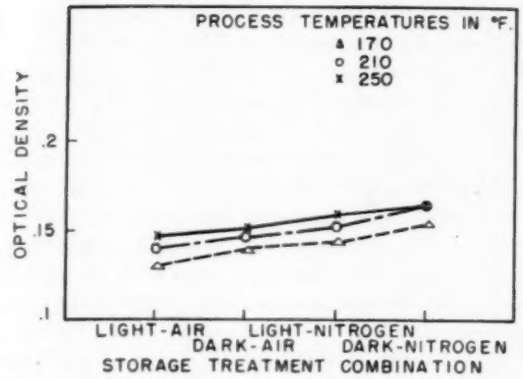

Figure 2. Variation of pigment concentrations of grape juice samples with storage treatments averaging over other variables except process temperature. Pigment concentrations are expressed as average values of optical densities at 515 mμ at pH 1.0 of solutions (1:100). Storage temperature was 70 ± 0.5° F.

ples were stored in the dark. However, the data shown in Figure 4 definitely lead to the conclusion that the period of storage exerted the maximum influence on the deterioration of the pigment and suggest that the rate of deterioration of pigment is proportional to the temperature of processing. The deterioration in the anthocyanin content of pure pigment solutions on heat and storage treatment appeared to be greater than the deterioration occurring in the juice samples wherein the pigments exist along with the other juice components. However, the formation of brown pigments during storage may have obscured the true relationship between grape juice and pure pigment.

The pigment concentrations in the juice samples after storage for 6 months could not be determined exactly as larger dilutions of the juice samples with dilute acid were employed to reduce the interference of the turbidities developed. The loss of pigment occurred primarily in the first 2 months while further storage periods did not involve comparable deterioration. During the storage period the juices changed from purple to light brownish red. A brown sediment settled to the bottom of the test tubes and the sediment increased with the period of storage. No effort was made to secure a quantitative estimate of the brown sediment. The data indicate that the amount of air dissolved in the juice samples is apparently sufficient to cause deterioration of the pigments, possibly by oxidation, as the presence of nitrogen in the headspace yielded results similar to those obtained with oxygen in the headspace. Pasteurization of grape juice samples or the addition of toluene brought about identical changes in the pigment concentrations as a result of storage period and storage treatments. Similar changes were observed in samples (processed from grapes stored at 40° F. for 1 month) processed for the longer times at temperatures of 210° F. and 250° F.

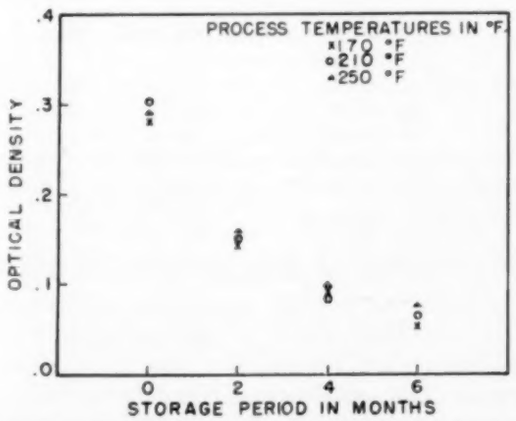

Figure 3. Variation of pigment concentrations of grape juice samples with storage period averaging over other variables except process temperature. Pigment concentrations are expressed as average values of optical densities. Storage temperature was 70 ± 0.5° F.

A study of the changes occurring in the pigment components during storage was made by use of a chromatographic technique using paper strips. With freshly prepared juices it was noted that two major bands were prominent on the paper column. The lower band with an R_f value of 0.12 was purple in color and the upper band with an R_f value of 0.21 was red in color. It has been suggested that the lower one was the diglycoside and the upper one the monoglycoside of the anthocyanidin *(9)*. With each juice sample the R_f values were determined under identical conditions and the average values were found to be 0.12 for the purple band and 0.21 for the red band. Spraying ammoniacal silver nitrate on the papers indicated faint brown bands, moving along with the solvent front and reducing silver nitrate in the cold. These brown bands were observed only with juices processed at temperatures of 250° F. for process times greater than 10 minutes. However, at the sites where the spots were initially placed, brown discolorations reducing ammoniacal silver nitrate in the cold were noted showing that some types of brown discoloration could not be moved by the solvent front.

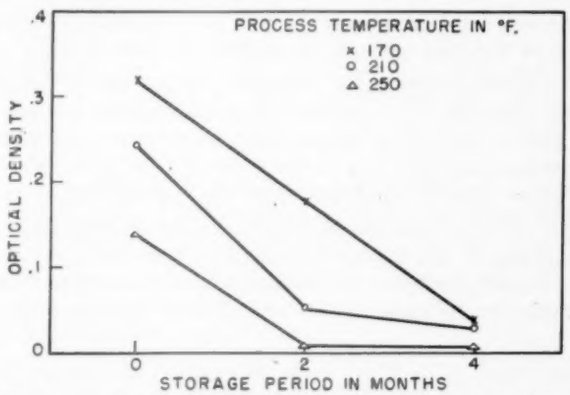

Figure 4. Variation of pigment concentrations of pigment solutions of pH 3.4 with storage period averaging over values for process times at each process temperature. The pigment concentrations are expressed as average values of optical densities at 515 mμ at pH 1.0 of solutions (1:50). Storage temperature was 70 ± 0.5° F.

At the end of each storage period each juice sample was separated by use of paper chromatograms under identical conditions. The intensities of the two bands were reduced progressively with storage and the lower band became much less intense than the upper one. A brown band also appeared at the top of the column moving along with the solvent front and this band was especially noticeable with the juice samples obtained after processing at higher temperatures.

On exposure of the papers to ammonia, two yellow bands at the top, one below the other, became prominent. Another band with an R_f value of 0.52, was revealed by a yellow color. All these bands reduced ammoniacal silver nitrate in the cold in the course of a few minutes. The brown discolorations at the site where the samples were placed on the paper columns, increased with storage. No special fluorescent properties were observed when these columns were examined under ultraviolet light, though the colors of the bands looked brighter than under daylight. Spraying dilute ferric chloride solution on the developed and air dried chromatogram produced a change in the color of the top band moving along with the solvent, to an intense yellow which faded rapidly. A light greenish band of R_f value 0.52, changing to grey in the course of 1 hour, was also noticed on spraying ferric chloride solution on the chromatogram.

SUMMARY

No regular variations in the anthocyanin pigment concentrations were noted in the grape juice samples on processing Concord grapes in glass jars at 170° F. for process times ranging from 31.5 to 79 minutes. When the processing was done at 210° F., the pigment concentration increased progressively as the process time was increased from 12.5 to 31.5 minutes, while a further increase in process time up to 100 minutes did not further increase the pigment concentrations of the juice samples. The pigment in juice samples processed at 250° F. for times longer than 63 minutes was found to undergo destruction.

These results indicate that the period of storage exerted the maximum influence on the deterioration of the pigment as compared to the presence of air or nitrogen in the headspace of the container, or storage of the samples in the dark or exposed to light. The amount of air dissolved in the juice samples is apparently sufficient to deteriorate the pigments, possibly by oxidation.

Both the mono- and the diglucosides of the anthocyanidin were found to decrease as a result of storage.

Studies on the effect of different processes on solutions of the major anthocyanin pigment (monoglucoside) indicated a gradual destruction of pigment with increased process time even at the lower tempratures of processing. On storage, the pigment concentrations diminished with simultaneous formation of gelatinous sediments in the solutions. The deterioration in the anthocyanin content on processing and storage was found to be more striking in the case of anthocyanin chloride solutions than in grape juice samples.

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Mechanical Refrigeration in the Transportation of Perishable Food[a]

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The development of mechanical refrigeration in the transportation of perishable foods is reviewed. The latest types of rail refrigerator cars and truck refrigeration systems are described, and future developments in the field are touched upon.

The importance of refrigerated transportation in our general economy and its history is not appreciated by many people. Therefore, let us briefly review the history of the refrigerator car which has had such a tremendous effect on the agricultural development of this country. Such agricultural developments include fruits and vegetables as well as animal products such as meats, eggs, and dairy products.

[a] Presented at the Eleventh Annual Meeting of the IFT, New York, N. Y., June 18, 1951.

EARLY HISTORY OF REFRIGERATED TRANSPORT

Prior to the early 1860's agricultural production was near the population centers for transportation was slow and expensive and refrigeration was not available for the transport of perishables. The first experiments in refrigerating produce were made in box cars about 1860 and generally consisted of placing ice in uninsulated cars. By 1870 enough progress had been made to show that here was a practical means for getting fresh peaches

from Michigan to New York, or dressed beef from Chicago to Boston, in good condition. As more and better refrigerator cars were built and used, with the consequent great expansion of markets for products, it became possible to concentrate the growing of fruits and vegetables in those locations most favorable for them. This led to the development of the California and Florida citrus industries, the planting of apples, pears, and cherries in the Pacific Northwest, and the production of a host of other commodities in various locations throughout the length and breadth of the United States.

From this crude beginning has emerged the present day modern refrigerator car with its steel construction, 4 to 4½ inches of insulation, air circulating fans, metal floor racks, side wall flues, easy-riding trucks, and many other mechanical and structural improvements. As a result of much experimentation and study over the years, the modern refrigerator car, using ice, now provides adequate transit conditions of temperature and humidity for a wide variety of products. The huge investment by the railroads in cars and icing facilities also means that any radical change in equipment will have to be well justified economically as well as make available a service that is at least as good or better than that obtained with ice.

Prior to the large expansion in the production of frozen foods since the early 1930's, the chief concern of the carriers was to develop equipment that would utilize most efficiently the refrigeration afforded by ice. Temperatures below 32° F. (0° C.) were not required in the shipment of fresh fruits and vegetables and temperatures between 20° and 32° F. (—7° and 0° C.) were easily obtained for meat shipments by adding various percentages of salt to the ice. For frozen foods, however, temperatures as low as 0° F. (—18° C.) are desired by the processors and shippers and such a low temperature cannot be maintained with ice and salt. Even today, the optimum storage and transit temperatures for frozen foods have not been definitely determined. A comprehensive study of the effects of different storage temperatures on all types of frozen foods is now being conducted by the Bureau of Agricultural and Industrial Chemistry. The results of this study may have far reaching effect on the industry.

After the frozen food industry became established, more and more interest developed in the use of types of refrigeration other than water, ice, and salt to achieve the desired low temperatures. These included use of dry ice, the split-absorption ammonia system, silica gel absorption system, and mechanical refrigeration. A number of different types of dry ice cars were developed and tested, but none have been accepted by the carriers at this time on any but an experimental basis. The silica gel absorption system was tried many years ago, but it was abandoned because of operating difficulties. Considerable interest has been shown in recent years in the split-absorption ammonia system, and tests with frozen foods conducted by the U. S. Department of Agriculture have demonstrated its ability to maintain low temperatures *(2)*. A number of cars were equipped, but they were never used in commercial service, because of operating difficulties in servicing them. This system operates by the expansion of liquid ammonia through the cooling coils after which it is absorbed by water. The ammonia is removed from the water by heating; this process requires rather extensive handling and facilities for its recovery. The ammonia and water tanks and piping add considerable weight and utilize all of the space underneath the car.

PRINCIPLES OF TRANSPORT REFRIGERATION

Before going into a discussion of mechanical refrigeration, I think it would be well to look very briefly into the principles involved in transport refrigeration. The fundamental concept of refrigeration is the removal of heat from a designated space or commodity. Heat will always flow toward a colder space, the rate of flow being determined by whatever material is in its path. Materials most highly resistant to such flow are used as insulation and their effectiveness depends on the thickness used. Refrigeration is accomplished by the removal of heat through the melting of ice, the sublimation of dry ice, or the evaporation of water or liquid refrigerants.

The function of transport refrigeration is two-fold. First, it has to cool warm loads to the desired carrying temperatures and then maintain that temperature throughout the transit period. This involves the removal of large quantities of what is termed "field" heat, and to do the job as quickly as is necessary with some perishables requires a rather large refrigerating capacity. The second function is to maintain the desired temperatures of precooled loads such as frozen foods or cold storage products such as winter apples or precooled vegetables.

Where warm loads have to be cooled, ample refrigerating capacity and adequate means of removing the heat from the load by air circulation are needed. Practically all commodities which are precooled in transport vehicles do not need to be cooled below 32° F. (0° C.) so that ice or ice and salt may be used satisfactorily with either built-in or auxiliary fans. Supplementary mechanical or ice refrigerating equipment is also used in many cases to precool warm loads. During the cooling period adequate air velocity and distribution are essential for quick cooling and uniform temperatures. Forced air circulation is needed in transit to remove heat that leaks into the car and that which the commodity evolves through respiration and to further cool the load in transit.

Since no insulation can stop the flow of heat completely, the amount of heat that does get through depends on two factors, the thickness of the insulation and the temperature differential between the outside air and the load space. The greater the temperature difference, the more heat can flow. For instance, where the outside temperature is 80° F. (27° C.), twice as much heat will flow in a given time through the walls of an insulated space when it is maintained at 0° F. (—18° C.) than would flow if it is maintained at 40° F. (4.5° C.). In order to prevent heat from warming the load, it must be intercepted by a moving current of air as soon as it comes through the wall.

RAIL REFRIGERATION

The benefits that might be obtained from mechanical refrigeration prior to the rapid development of frozen foods were far outweighed by the difficulties of adapting these units to the refrigerator car, which is subjected to shocks and vibrations, and by the problem of maintenance with available labor and equipment. However, with the demand for lower temperatures than could be maintained consistently with ice and salt, interest was reawakened and development carried to the point where we now have mechanically refrigerated cars in regular service.

Figure 1. A modern mechanically refrigerated rail car.

Because of the reluctance of the railroads to risk the fire hazard from use of gasoline for power and the lack of electricity or steam for power on freight trains, diesel engines were used in early attempts to mechanize rail refrigerator cars. The cost and size of these early diesel engines were discouraging but several experimental installations were made. One of these early experiments utilized cooling coils placed in the side walls and extending the full length of the car, but the shock and vibration caused numerous leaks in the refrigerant piping. Finned coils placed under the ceiling of the car were also used but they too developed leaks.

Practically all of the recent developments have utilized the circulation of refrigerated air through the car, which permits the grouping of all the refrigerating equipment in a compact engine space in one end of the car. The development of the unit coolers and improved controls and small and lighter diesel engines have made it possible to build refrigerating systems that withstand rough handling and maintain temperatures in the cars at or below 0° F. (—18° C.). One of the two types of installation now in service utilizes gasoline engine power with two complete units per car. While these gasoline units are now in regular service on eastern seaboard lines, there is still considerable reluctance on the part of many railroads to accept them, because of the highly volatile nature of their fuel.

All the new mechanical cars have side or end wall flues or racks and floor racks which hold the load away from contact with the outer shell of the car. Refrigerated air is blown out over the load down the space between the walls and the load and back to the unit under the floor, or in the reverse direction, under the floor racks and up between the load and walls and back over the top of the load to the intake of the unit.

The first mechanically refrigerated car tested by the Department of Agriculture was the Thermo-King unit investigated in cooperation with the Fruit Growers Express Co. This system was designed for both frozen and fresh commodities to protect the load in cold weather by furnishing heat as well by supplying refrigeration in warm weather. Each of the two units is powered by a 4-cylinder gasoline engine directly connected to the compressor. The engine, compressor, evaporator, condenser, and fan are all built into a compact unit which is complete in itself and contained in an insulated compartment in one end of the car. The rated capacity of the compressor is approximately one ton at 0° F. (—18° C.). The equipment was originally developed for refrigerated trucks and has been in use for several years. The Model RY units used in the refrigerator car are similar to the heavy duty truck model for frozen foods. Two units are installed per car and are mounted at one end of the car on a sliding base to permit the unit to be pulled out of the car for inspection and servicing. By removing the fuel and control connections, one unit may be removed and replaced with another in a matter of minutes. One of the distinguishing features of this system is that the engine automatically starts and stops in response to the controls. As the blower fan is inoperative when the engine stops, an auxiliary fan, powered by the engine starting batteries, is used to maintain air circulation. Another feature of the Thermo-King system is the provision for heating by the use of the reverse cycle system in which the hot refrigerant gas is pumped into the evaporator instead of the condenser. The temperature control for both heating and refrigerating is set so that only one unit will start operating at first, but if the refrigeration load is too great, the second unit starts. Signal lights mounted on the outside of the car indicate whether the unit is refrigerating, heating, or not operating. Fuel capacity is sufficient to operate for 7 to 10 days without refueling. These cars are equipped with the new 6-foot sliding doors for accommodation of fork lift trucks and pallet loading and all the latest structural and operating features of the modern refrigerator car and include 6 inches of the latest type insulation.

The first test conducted on this car was made to determine its effectiveness in furnishing heat for the protection of apples shipped in winter *(4)*. Although the weather was too warm for a good test, commodity temperatures were maintained within 2° F. of the thermostat setting of 34° F. for the entire 6 days in transit. In cooperation with the Production and Marketing Administration, two refrigeration tests were conducted with this equipment last year with frozen citrus concentrate from Florida to New York with highly satisfactory results. Eleven cars of this type including the experimental or prototype car are now being operated by the Fruit Growers Express Company for frozen concentrate shipments on the east coast and the information obtained indicates that performance is satisfactory.

At the same time that the Fruit Growers Express Co. was pioneering the Thermo-King car in cooperation with the U. S. Thermo Control Co., they were also cooperating with the Frigidaire Division of General Motors Corporation in the development of a system powered by a diesel-electric unit. One experimental car was built and tested for over a year before production models were ordered and built. Fifty-two of these cars have now been put into service, mostly for the frozen citrus concentrate traffic from Florida to eastern seaboard destinations. One hundred more, to be installed in 50-foot giant size cars, are now on order and will be delivered during the coming year. For the present these will be used exclusively in the movement of frozen food.

The Frigidaire system employs forced circulation of cooled air around the load and delivers the cooled air at the top of the load instead of at the bottom as in the Thermo-King system. The system is powered by a diesel-generator unit of 20 kw. capacity. The diesel engine operates continuously while the car is in service. The refrigerating unit consists of a motor-driven 2-cylinder compressor and condensing coils mounted in a compact unit. The refrigerating capacity of this compressor is approximately 2 tons of refrigeration at 0° F. (—18° C.). One compressor is used for the 40-foot car, while two in tandem are used in the 50-foot car. The cooling coils, electric defroster, and air circulating blowers are mounted in an insulated chamber which is separate from the engine compartment. All equipment is mounted in one end of the car. Both the 40-foot and the 50-foot cars have approximately 2 feet more loading space than the standard cars of these dimensions fitted with ice bunkers. The thermostat control for the operation of the electrically driven compressor unit is of the same type as commonly used in commercial refrigeration installations. Blowers operate continuously except while the evaporator is being defrosted. The defrosting cycle is controlled by an electric timer. No provision is made for heating the load for protection against cold as is done with the Thermo-King. Ample fuel capacity for up to two weeks of operation without refueling is provided by tanks mounted underneath the car. A valuable standby feature of this car is that it may be plugged to any 220 v., 3 phase, 60-cycle current and be operated independently of its power unit. The car also has 6 inches of insulation, 6-foot sliding doors, and all the other latest mechanical features. This experimental unit was also run in the test with frozen citrus concentrate last June and maintained

temperatures well within the zero degree range as shown in Figure 2 *(3)*.

The Santa Fe Refrigerator Department also has been experimenting with mechanical refrigeration. A diesel-powered unit somewhat similar in design and operation to the Frigidaire unit was built by the Trane Company and installed in a refrigerator car that was tested with a number of commodities. The original specifications, as presented by Daley *(1)*, called for equipment that would fit into a regular refrigerator car with no change

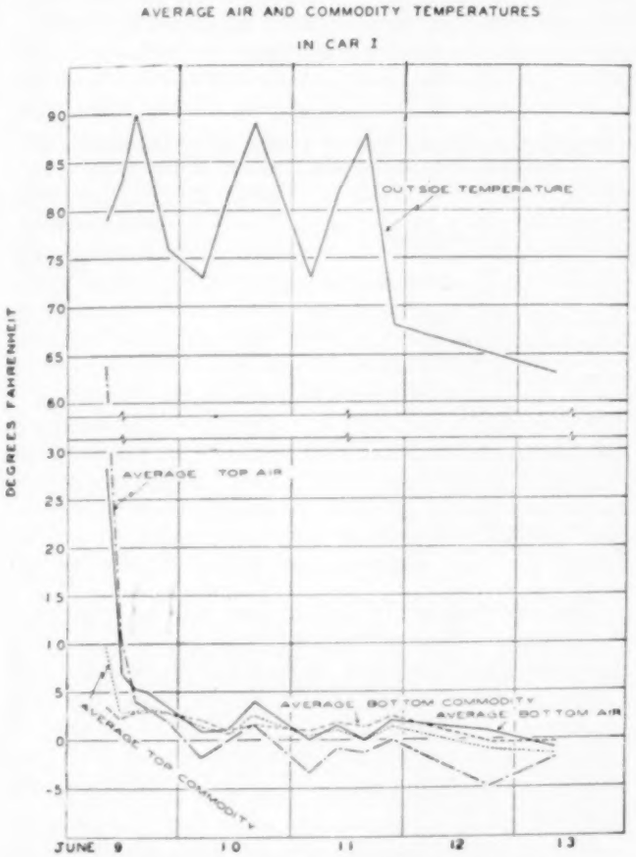

Figure 2. Air and commodity temperatures in mechanically refrigerated car loaded with frozen citrus concentrate.

in basic dimensions or structure; that would have such capacity and range in temperature control that it could be used for all commodities from bananas to frozen foods including means for heating to protect against cold; that would be able to withstand the shocks incidental to freight service; that would have sufficient capacity to precool hot loads of produce; and that would maintain proper humidity for highly perishable commodities. The results of tests conducted by the Santa Fe Refrigerator Department showed that all these requirements have been met and plans are underway for building a number of these cars for regular service.

The advent of the mechanical car has naturally required the training of personnel to provide for proper maintenance and operation of this equipment. Trained mechanics are stationed at division points along the route to check the operation of the cars. To date, this equipment has met a number of severe tests in rough handling including derailment and turning over.

Refrigeration charges for all types of mechanical refrigeration are based on Rule 171 of Perishable Protective Tariff No. 15, which is the charge for standard refrigeration plus an additional charge of 50%. This is the same charge as for ice plus 30% salt. For fresh fruits and vegetables the charge is the same as for standard refrigeration.

Thus, the chief advantages of mechanical refrigeration in rail cars are that of maintaining lower temperatures for frozen foods than ice and salt can do; the elimination of some of the weight of excess ice; heating as well as refrigeration with the same equipment; and the elimination of the corrosive action of water and brine on cars and tracks. When mechanical refrigeration is perfected, temperature control at any desired level may be possible. Among the disadvantages are high initial cost; possibility of breakdown many miles from repair facilities; requirement of highly skilled personnel for maintenance; and probable high depreciation rate as compared with the regular ice refrigerator car. An all-purpose car would need a large enough compressor and enough coil surface and air volume to precool warm produce in the time that precooling could be done in the ice refrigerated fan car.

It should be noted that other mechanical systems are in the design stage and are being developed by the manufacturers of refrigerating equipment, car lines and other concerns. With greater competition, improved designs and equipment can be expected and all indications are that we are on the threshold of the era of mechanically refrigerated rail transport.

TRUCK REFRIGERATION

During the past year, the Department of Agriculture conducted a series of tests on the transportation of frozen citrus concentrate from Florida to eastern and midwestern destinations *(3)*. The purpose of this study was to obtain information on the temperatures maintained throughout the load by various transportation facilities currently available. Included were both rail and truck equipment. Some of the rail results were presented above. Tests were made on 23 trucks, over half of which were accompanied by observers and considerable data were obtained on equipment and its performance.

The truck trailers included in the tests and shown in Figure 3, had 6 inches of insulation and were 30 to 34 feet long. They were all designed specifically for frozen food service and most of them were comparatively new.

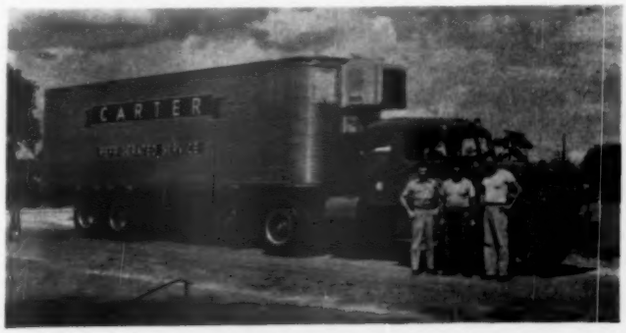

Figure 3. A modern mechanically refrigerated truck-trailer.

One of the first firms to supply mechanical refrigeration for trucks and now furnishing most of the refrigerating equipment used in the truck movement of citrus concentrate from Florida is the U. S. Thermo Control Co. (Thermo-King). Twenty of the tests were made with this equipment. This unit is similar to that previously described for the refrigerator car. It is a complete unit mounted in the nose of the trailer up against the ceiling. The engine and compressor are mounted on the outside, and the evaporator and air circulating fan are within the trailer. Cold air is blown out through a narrow opening in the top of the unit and the return air is drawn back into the opening immediately below. Operation is thermostatically controlled with the compressor starting and stopping as required.

The first series of tests indicated that there was not proper air circulation around the load and that hot spots resulted in certain positions in the load. These were generally on the floor next to the side walls. While the top of the load was cooled adequately by the direct blast of air from the unit, the lower layers were bypassed as there was no means by which air could be positively drawn back under the load or down the sides, thereby intercepting the heat coming through the insulation as discussed previously. The curves in Figure 4 show the differences in temperature between the top and the bottom layers. In order to improve circulation, a return air duct was constructed to drawn the air from the floor at the front of the trailer instead of at the top as normally done. When proper baffling was used, very little air could be drawn back into the unit except by travelling along the floor strips under the load. In order to increase the movement of air down the side walls, which had 5/8 inch strips about 12 inches on center to hold the cases away from the wall, the bottom layer of cases was loaded one row short across the trailer; this provided a channel approximately 4 inches wide the full length of the trailer next to the walls. In this way a channel for drawing the air down the side walls was provided.

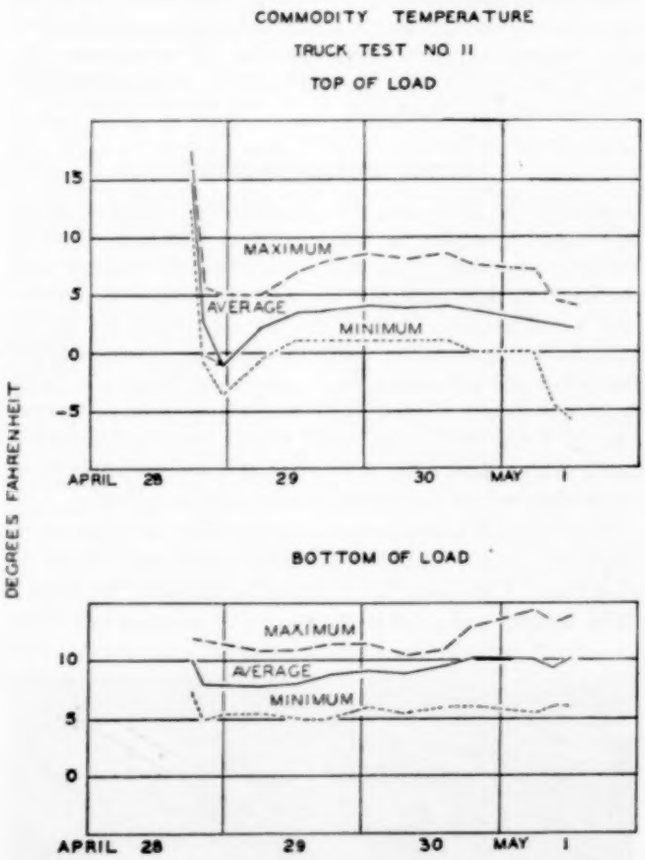

Figure 4. Top and bottom commodity temperatures in a mechanically refrigerated truck-trailer.

While temperatures in the load of 10° F. (—12° C.) and higher were found in trailers without this modification, uniformly low temperatures as shown in Table 1, were obtained by the use of the duct.

TABLE 1

Comparative temperatures of frozen citrus concentrate in modified and conventional trailers at unloading

Position in load	Temperature of frozen citrus concentrate	
	Modified trailer	Conventional trailer
	° F.	° F.
Bottom bunker, right side	3	10
Bottom bunker, left side	1	10
Bottom bunker, centerline	1	10
Bottom half, right side	3	4
Bottom half, centerline	0	0
Bottom half, left side	3	8
Bottom door, right side	3	8
Bottom door, centerline	2	6
Middle half, right side	—1	—2
Top bunker, centerline	0	6
Top half, centerline	0	3
Top door, centerline	0	4
Top door, left side	2	6

This improvement in performance is being brought to the attention of the manufacturers of both the unit and the trailers and steps are being taken to re-design the system to improve the air circulation along the lines suggested. Improved air circulation is to be used in other types of trailers for fresh produce for both precooling hot loads and maintaining uniform temperatures in transit.

Several manufacturers are working on truck refrigeration and improvements in design and performance are certain to be forthcoming in the near future.

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Some Practical Problems in the Introduction of New Food Products[a]

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The problems involved in the introduction of new food products are reviewed.

The number of problems that demand consideration in the introduction of new food products is large. After the initial idea has been conceived, the laboratory and pilot plant studies made, and the decision has been reached to proceed with the development of the idea, there arise problems of packaging and package sizes, labeling, the determination of selling price, probably the details concerned with the making of a market test of the product and the review of its results, the creation of basic advertising themes, the allocation of advertising in different media and the preparation of suitable copy, coordination of production, advertising and selling, the instruction of the sales force, and final marketing.

Regardless of the size of a company, responsibility for the successful solution of all problems concerned with the introduction of a new food product rests, of course, with management. The scientific department, which has sometimes been thought of as being wholly concerned with technological research and quality control, and the solution of production problems, can and should contribute to overall management consideration of every phase of new product development. The trend today is in the direction of relying more on the food technologist for such help as he can properly contribute to the solution of the problems of other departments.

Just as it is true that the scientific department has something to contribute to other divisions of a company, it is equally true that other departments can contribute to the work of the group which is primarily responsible for the development of new items. As scientists, some of us may think at times that the sales or advertising departments have more to say about new products than is wise, but I think we would freely admit that many good ideas come from the men who eventually have to sell the products. There is also the fact, generally recognized by the experienced technologist, that a spirited desire to sell a new product exists, when the idea for it has originated in the sales department.

Modern business requires team work. It is highly desirable for the technical or scientific departments to recognize some of the practical problems encountered by the other departments, not only advertising and sales, but problems of the legal department and management as well, before a laboratory item can be produced and successfully marketed.

There is a limitation to the number of classes of foodstuffs, so that we in the food industry recognize that no new product is entirely unique. It may be new in the sense that it is different from presently available products with which it logically may be compared. More often a new food product is simply an improved form or a more convenient form of a familiar item of the diet.

Changes in equipment or in methods of production may alter the characteristics of a food item sufficiently to give a different product. A new package may mean a new product to the consumer. An improperly revised label may make a satisfactory product illegal for sale in interstate commerce. The point is that any change in a product, its ingredients or production, its packaging or its labeling, needs thoughtful consideration, for it may involve many of the problems of an entirely new article.

New food products, or improved food products, usually have their origin in one or more of several ways. They are developed:

1. To fulfill a demand for a particular or different kind of product. This demand may arise from consumers or from other sources. Every new product, to be successful, must fulfill a consumer demand. Sometimes this demand is expressed, but more frequently it has to be sought and subsequently developed by suitable advertising and promotion.
2. As a result of new packaging materials or methods, improved distribution or problems concerned therewith, or new processing techniques and equipment.
3. To make wider use of available materials. These materials may be in part a by-product of regular production, or they may represent agricultural products that are abundantly available.
4. As a result of the introduction of new ingredients, or the use of new formulas, or by readjustment of the components of natural foods.

A new food product is not necessarily an improvement over an established product. From the consumer's point of view it may be a poor substitute, in eating quality, for example, but acceptable to a limited extent for other reasons. Each year many new food products are announced. Some are successful, many are not and become forgotten items in the history of the food industry.

Consideration of certain phases of marketing and of other matters must enter early in the development of a new food product, if success is to be made more likely. What is the extent of the possible market for the product? What obstacles exist for its production and sale? Where does it fit into the established order of company operations? How, too, does it fit into the dietary customs and purchasing habits of consumers? These are some questions to which management must give consideration even before extensive effort is devoted to new product development. Unfortunately, these questions cannot be answered in general terms, for each product presents different problems. They are mentioned as matters which should be considered by

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the technologist early in the work of developing ideas for new products.

The food industry, unlike the chemical and pharmaceutical industry, is fortunate in that a long market life may be anticipated for items which gain acceptance. Recently an executive of a leading chemical manufacturer asserted that 70% of his company's current sales were of products that were not manufactured, and most of which were unknown, fifteen years ago. The president of a long established pharmaceutical company pointed out to his sales staff that the preparations which accounted for the bulk of the company's business were all less than five years old. Contrast this situation, and the problems of great expense concerned with research, and of securing of an adequate return on a large investment for equipment which may become obsolescent overnight, with the situation that prevails within the food industry. Here, some brand named items have been sold continuously for more than fifty years, and other products have been marketed since the beginning of the food processing industry. There have been changes, of course, in practically all products over the years, but the fact remains that a food product has dietetic and culinary values which may justify its sale long after any element of novelty connected with it initially may have worn away.

Even special foods have a longer life than might be thought. At one time gluten breads had considerable vogue as foods which were specially useful in the diabetic diet, because of their lower carbohydrate content. The introduction of insulin and of newer methods in the management of diabetes made gluten breads and many other so-called diabetic foods much less important. These products continued to be produced, however, although in limited quantities. Recently, there has been renewed interest in gluten bread, and some of the special breads, because of their somewhat higher protein content.

The rise and decline in the demand, and hence in the sales of dietetic foods, depends in large measure on the developments in nutritional and medical science. Today we are witnessing a resurgence of interest in canned water-packed fruits and vegetables, owing to the general recognition of the benefit to certain patients of low-sodium or low-calorie diets, and the usefulness of these products in their formulation.

The legal requirements pertaining to foods need attention early in the development of new products. A general understanding of what can and what can not be done under existing legislation can save a great deal of time and expense. One of the important provisions of the Food, Drug and Cosmetic Act of 1938 is the authority vested in the Administrator to develop definitions and standards of identity for food products. A limited number of products has been defined to date. The development of improved foods, when these are foods for which a standard of identity has been established, is possible, but the articles may not be sold until the standards have been changed. Substantial evidence is necessary to bring about an amendment to the standards, and there is a definite procedure that must be followed. Whenever test marketing to determine consumer acceptance of a non-conforming product is considered necessary, there exist provisions for carrying out such tests. It is advisable for manufacturers to present their problems or their questions in this connection to the Food and Drug Administration, Washington, D. C.

In addition to the Food, Drug and Cosmetic Act, and regulations and administrative rulings based thereon, other federal statutes may need to be considered, such as the Meat Inspection Act, the Filled Milk Act, etc. State laws and, at times, municipal regulations, need attention. The requirements of foreign countries must be met whenever marketing in those areas is contemplated.

Most of the legislation pertaining to foods was enacted for the purpose of correcting certain practices which, on the basis of existing information when the legislation was passed, were considered to be contrary to the public interest. The food laws protect the health of consumers. They also protect legitimate industry from unfair trade practices.

It has been asserted that the existence of food standards serves to retard progress and acts as a deterrent to research in the development of improved products. I do not know of any instance where the public has been deprived for long of anything important because of the existence of food standards. On the other hand, I think many examples could be cited where needed research has been stimulated, owing to the existence of standards and other regulations, and the necessity of presenting factual evidence in order to gain recognition of a new development. Examples could be cited, also, of disadvantages to companies and to segments of the food industry, that have resulted from the fact that many food products still remain unstandardized, so that changes could be made in the products without the benefit of the rules provided by standards.

Whenever a new food product conflicts with legislation or with regulations, and there is reason to seek a change in the law requirements, there are three procedures available. First, it is often possible to explain the facts to regulatory officials and thereby secure fairly promptly a different interpretation of existing rulings. Second, it may be necessary to develop through established procedures a change in regulations. Finally, new legislation may be necessary, and this involves a complicated and lengthy process. Twenty years elapsed between the commercial production of carotene and its approved use to color margarine and, at the same time, to increase its nutritive value.

Any new food product must meet the requirements of the law. It must be clean and free from contamination with extraneous materials, and contain no harmful or deleterious ingredient. It must be wholesome, free from spoilage or harmful bacterial organisms, and safe to eat. It cannot be deceptively packaged, and it cannot purport to be something better than it is. The food must comply with the requirements in the regulations for standardized products, or declare unless specifically exempted all ingredients properly on the label. The labeling must be informative and contain no misrepresentation of fact. These general requirements pertain to all foods.

A good food in addition meets the following requirements, which are not so rigidly demanded by existing legislation, for a successful product:

1. It contains no inadequately tested ingredient that may be harmful, or the use of which results in the lowering of the nutritional value of the food.
2. The product is formulated, or processed, or both, in a manner that assures the retention of the expected nutritional value of the food, to the greatest possible extent consistent with the other requirements of a good food.
3. It has good eating qualities of itself, or it contributes these qualities when used according to fairly simple directions, which are provided.
4. The product is truthfully and informatively represented in its advertising and promotion.
5. The product is readily available to consumers, attractive in appearance, and sold at a reasonable price.

New food products which have been eminently successful in recent years are found to be those which meet these five requirements. Products which have been unsuccessful are those which have failed in signal fashion from measuring up to one or more of these requirements. There are a few seeming exceptions, in that some so-called improved foods, which in the opinion of some persons have no meritorious reasons for ever being introduced, still are being marketed. This condition is probably a temporary one that will be corrected by the industry or by the consuming public in due time.

The important criterion to be applied to any proposed new product is simply that it must possess real merit from the consumer's point of view.

Food Preferences of Pre-Army Age California Boys[a]

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In cooperation with the Research Division of the Quartermaster Food and Container Institute, a study of attitudes toward 258 foods and toward typical preferred menus was carried out on 144 boys, 17 to 19 years of age, in northern California. A composite rating was worked out for each of the foods studied.

During World War II a major issue in ration utilization was the non-acceptance of items which had been found desirable as to nutrient value and keeping qualities during storage under extremes of heat and cold. The importance of this problem was brought out by the Quartermaster Food and Container Institute in 1946 *(1)*.

In the planning of meals for large numbers of people, in the production and processing of food, as well as in planning military rations, the acceptance of food is a factor to be considered. The nutritional benefits of the food and its economical use depend on actual consumption which in turn depends on preferences and palatability. Other than a few isolated studies, available information relating to this question has to do chiefly with production rates which refers to supply rather than actual acceptance.

Before the reasons for non-acceptance of foods can be determined, it is necessary to know the relative acceptance of foods. Acceptance or non-acceptance is affected by the food habits of the individual, which are determined by such factors as age, sex, national-racial grouping, economic status, geographical location, availability of the food as influenced by processing and transportation, etc. When these factors have been taken into account, the items rated low in acceptability can then be studied to determine reasons for their non-acceptance, such as emotional prejudices, physiological reactions to the food, poor cooking methods, flavor dislikes, unfamiliarity, or other factors. Results of this type of study may be helpful to the food processor in the promotion of a wide variety of acceptable foods.

[a] This paper reports research undertaken in cooperation with the Quartermaster Food and Container Institute for the Armed Forces, and has been assigned number 364 in the series of papers approved for publication. The views or conclusions contained in this report are those of the author. They are not to be construed as necessarily reflecting the views or indorsement of the Department of Defense.

The work here presented was done in 1946-47 under the direction of the Quartermaster Food and Container Institute of the Armed Forces, and was concerned with the food preferences of a group of pre-army age boys in California.

MATERIAL AND METHOD

Regions sampled. The persons interviewed were selected from 49 counties north of San Luis Obispo, Kern, and San Bernardino counties, in northern and central California. Most of the citrus belt was omitted. The total population of this area, as taken from the Sixteenth Census of the United States, 1940, was 3,066,654. Samples were taken from each county, or, if the counties were sparsely populated and of similar topography, from the center of two or three adjacent ones.

Method of sampling. Only boys from 17 to 19 years of age were included. A 200-person sample was selected, which was about 0.16% of the males 15 to 19 years of age in the area sampled. The selection of the boys in each county was determined by the total population of the county, the proportionate number of racial-national groups, and the rural and urban population. A final total of 144 questionnaires was processed, 112 from urban areas and 32 from rural.

Method of interviewing. The interviews were obtained through the cooperation of the high schools. From 4 to 6 students met together during a study period and recorded the necessary information under supervision. To avoid fatigue, interviews were conducted for one-hour intervals on different days. A total of from 6 to 8 hours was needed for most of the questionnaires. Illustrative material, particularly pictures and descriptions of fruits and vegetables, helped the boys identify the foods.

Material studied. Information as to preference was obtained on 453 different food items of which 258 (those for which the most data were secured) were analyzed and studied. Space was available for listing preferred and disliked methods of preparation. In addition, each boy recorded a desirable day's menu for a weekday (Wednesday) and for a Sunday, and some general information regarding his background. The questionnaire form used is reported in Appendix B of the food preference study made in Iowa by Eppright *(2)*.

RESULTS AND DISCUSSION

Preferences for selected foods. Food items were rated by the questionees as very good, good, moderate, tolerated, disliked, or not tried. To obtain some sort of scale rating for each food, the following formula was used in arriving at a "composite rating":

$$\frac{[(\%\text{ very good})\ 2 + (\%\text{ good})\ 1 + (\%\text{ moderate})\ 0 - (\%\text{ tolerate})\ 1 - (\%\text{ dislike})\ 2] \times 100}{100 - (\%\text{ no answer} + \text{not tried})} = \text{composite rating.}$$

If 100% of the respondents checked the food preference as "very good", the rating would be a plus 200; if 100% checked "disliked", the rating would be minus 200. These are the extremes of the composite rating. Correction was made if the food had never been tried or had been omitted, so that the rating represents only the cases where a judgment was checked. Since the number of rural respondents, 32, was relatively small, both urban and rural groups were treated as one for the ratings and the preferred methods of preparation. The ratings are presented alphabetically under food groups in Table 1.

The median composite rating of all items was +89, approximately "good". The distribution of the ratings is given in Figure 1.

Foods receiving the highest ratings (200 to 160) were, in order of preference, bananas, ice cream, fruits, strawberries, pies, peaches, beef steaks, turkey, pineapple, fruit juices, milk products, butter, meats, and sweet corn. Those with the lowest ratings (—60 to —140) were collards, dandelion greens, kidney, turnip greens, parsnips, red snapper, rutabaga, kohlrabi, heart, turnip roots, buttermilk, kale, escarole and beet tops, in that order. The rating of a food group, such as vegetables, may or may not be related to the ratings of the individual items. For example, although vegetables as a group re-

TABLE 1

Composite ratings of foods, listed alphabetically under food groups[b]

	Composite rating
VEGETABLES	111
Artichokes	74
Asparagus	59
Beans, in pod	66
Beans, shelled	74
Beet tops	—64
Beet roots	8
Broccoli	—21
Brussels sprouts	—34
Cabbage	22
Carrots	101
Cauliflower	—7
Celery	110
Chard leaves	—5
(Chinese cabbage)	—16
Chives	—16
(Collards)	—140
Corn, field	102
Corn, sweet	160
Cucumbers	49
(Dandelion greens)	—125
Eggplant	—44
(Endive)	—27
(Escarole)	—65
Garlic	—15
Kale	—67
(Kohlrabi)	—79
Lentils	3
Lettuce	129
Mushrooms	3
(Mustard greens)	—48
(Okra)	—30
Onions	58
Parsley	23
Parsnips	—87
Peas in pod	53
Peas, shelled	97
Peppers	0
Pimientos	—38
Potatoes, sweet	56
Potatoes, white	153
Pumpkin	86
Radishes	54
Rhubarb	22
(Rutabaga)	—80
(Salsify)	—57
Sauerkraut	—14
Soybeans	—47
Spinach	81
Squash	15
Succotash	12
Tomatoes	137
Turnip greens	—100
Turnip roots	—77
(Watercress)	6
Yams	49
Vegetables, beverages	24
Vegetables, pickles	33
Vegetables, salads	105
Vegetables, soups	123
FRUITS	181
Apples, cooking	148
Apples, dessert	146
Apricots	134
Avocado	8
Bananas	191
Blackberries	154
Blueberries	115
Boysenberries	141
Cherries, sour	40
Cherries, sweet	152
Cranberries	109
Currants	25
Dates	41
(Dewberries)	100
(Elderberries)	85
Figs	43
Gooseberries	49
Grapefruit	92
Grapes, dessert	143
Grape juice	101
Huckleberries	106
Lemons	98
Limes	66
Loganberries	124
Melons, garden	140
Watermelons	152
(Mulberries)	31
Nectarines	106
Oranges	155
Peaches	171
Pears	134
Persimmons	—18
Pineapple	170
Plums	101
Pomegranate	47
Prunes	47
Quince	—16
Raisins	78
Raspberries, black	129
Raspberries, red	124
Strawberries	178
Tangerines	108
Youngberries	116
Fruit bars	41
Fruit cakes	90
Fruit juices	165
Fruit salads	143
NUTS	121
Almonds	134
Peanuts	133
Pecans	99
Walnuts	107
Nut butter	81
CEREALS	78
Breakfast cereals	74
Uncooked or quick cooking cereals	34
Cracked grains	—8
(Farina)	41
Mushmeal and grits	20
Popcorn	92
Rolled oats	20
Whole grains	19
Whole wheat	16
(Other uncooked cereals)	8
(Ready-to-eat cereals)	66
Corn cereals	56
Mixed cereals	29
Oat cereals	24
Rice cereals	70
Wheat cereals	56
Other ready-to-eat cereals	35
Griddle cakes	136
(BREADSTUFFS)	106
Biscuits	138
Doughnuts	156
Dumplings	86
Muffins	124
(Popovers)	106
Rolls	143
Sandwiches	139
Waffles	157
Bread, corn	77
(Bread, oats)	10
Bread, potato	89
Bread, rye	57
(Bread, soybean)	—27
Bread, wheat	109
(Other breadstuffs)	88
CRACKERS, COOKIES, SWEET GOODS	134
Biscuits or crackers	111
Cakes	153
Cookies	134
Pies	173
Other pastries	145
Puddings	112
MACARONI PRODUCTS	100
Macaroni	104
Noodles	96
Ravioli	119
Spaghetti	132
(MEATS)	160
BEEF AND VEAL	157
Chili con carne	84
Chop suey	—1
Chuck	104
Corned beef	72
Veal cutlet	123
Dried beef	53
Frankfurters	113
Ground meat	131
Heart	—78
Kidney	—114
Liver	—6
Porterhouse	167
Ribs	129
Round	144
Rump	101
Salami	76
Sirloin	166
Soup	118
Stew	95
T-bone steak	171
Tenderloin	171
Tongue	—26
Leg of veal	115
(Other beef or veal cuts)	108
PORK	109
Bacon	150
(Butts)	—55
Chops	145
Gelatin	22
Ham	154
Loin	95
(Pig's feet)	58
Salt pork	3
Sausage	99
Shoulder	106
Spare ribs	116
Tenderloin	135
LAMB AND MUTTON	89
Breast of lamb	85
Ground round patties	59
Lamb chops	143
Leg of lamb	136
Shoulder	84
Stew	71
Chicken fryers	155
Chicken roasters	135
Duck	96
Egg, chicken	110
Goose	83
Turkey	171
DAIRY PRODUCTS	158
Milk products	163
Butter	161
Cream	142
Ice cream	182
Buttermilk	—69
Milk, evaporated	—29
Milk, sweet whole	149
Sherbet	105
CHEESES	121
American	135
Cottage cheese	70
Cream cheese	75
Swiss	83
FISH	30
Oysters	—7
(Red snapper)	—75
Salmon	88
Sardines	45
Shrimp	101
Tuna	135
(CONFECTIONS)	134
Candy bars	138
Chocolate	151
Fudges	115
Hard candies	49
Marshmallows	122
(BEVERAGES)	91
Soft drinks	143
Chocolate and cocoa	127
Coffee	43
Tea	26
(CONDIMENTS AND FLAVORINGS)	67
Cinnamon	109
Cloves	24
Ginger	62
Pepper	66
Garlic salt	26
Almond	57
Vanilla	135
Catsup	107
Chili sauce	68
Mustard	86
Pickles	106
Margarine	23

[b] Parentheses indicate no answer or that food was not tried by 50% or more of subjects.

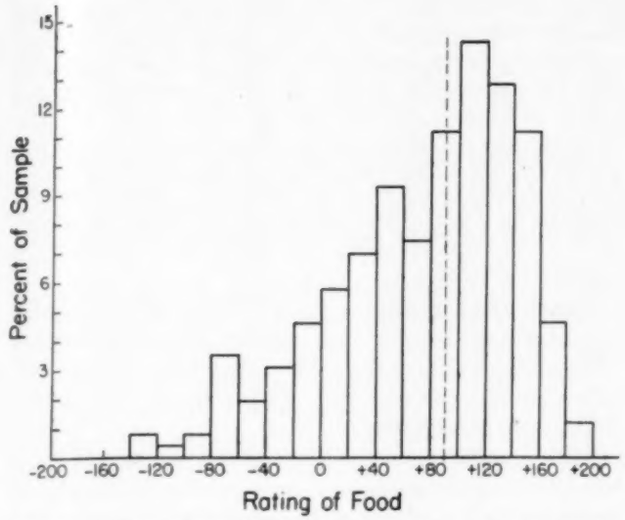

Figure 1. Percentage distribution of ratings of 258 foods.

ceived a value of 111, only 6 individual items were rated 100 or over, field corn, celery, lettuce, tomatoes, white potatoes, and sweet corn. The other 48 vegetables received ratings of from 97 to —140.

The foods disliked by 20% or more of the questionees are shown in Table 2. Buttermilk was disliked by the largest number of boys. The organs of animals, and some vegetables, such as turnips, members of the cabbage family, eggplant, and parsnips, also were disliked

TABLE 2
Foods disliked by 20% or more of subjects

	%		%
Buttermilk	53	Avocado	26
		Cauliflower	26
Kidney	39	Broccoli	26
Turnip roots	37	Soybeans	25
Eggplant	34	Pig's feet	24
Turnip greens	32	Rutabaga	24
Parsnips	32	Rhubarb	24
Brussels Sprouts	32	Garlic	24
Liver	31	Chop suey	23
Heart	31	Squash	23
Sauerkraut	31	Peppers	23
Oysters	30	Pimientos	23
		Sardines	22
Beet tops	29	Coffee	21
Mushrooms	28	Persimmons	21
Tongue	27	Tea	20
Evaporated milk	26		

by many. It is realized that this type of questionnaire tests attitudes toward foods, and many items may have been checked as "disliked" which had never been tried. Poor methods of preparation, emotional attitudes learned from others, and similar factors are represented in the rating.

Table 3 contains the foods which had not been tried by 20% or more of the boys tested. Types of fruits and vegetables, such as salsify, collards, dandelion greens, kohlrabi, escarole, dewberries, elderberries, endive, Chinese cabbage, mulberries, and lentils, were most unfamiliar.

Comparison with Iowa study. Eppright, in 1950 *(2)*, also in cooperation with the Research Division of the Quartermaster Food and Container Institute, reported a study of the food habits and preferences of 1,051 persons in two age groups, 17-19 and 46-58, living in Iowa. Both men and women were included. Of the total number, 126 were males, 17-19 years of age. Data on preference in Eppright's study *(2)* are given for the total sample, so that any comparison includes possible sex and age differences as well as geographical area. Nevertheless, there are some differences which may be noted.

Cabbage, onions, and sauerkraut were rated more desirable by the Iowa group (that is, the sum of the percentages for "very good" and "good" was greater than that of the California group by 10 or more). Similarly, foods rated more desirable by the California sample were lamb chops, turkey, milk, many of the

TABLE 3
Foods not tried or not recognized by 20% or more of subjects

	%		%
Salsify	85	Currants	44
		Turnip greens	44
Collards	79	Succotash	41
Dandelion greens	76	Chives	40
Red snapper	75		
Kohlrabi	73	Heart	39
Escarole	73	Peas in pod	39
Dewberries	72	Persimmon	38
Elderberries	71	Kidney	36
Endive	71	Pig's feet	35
		Blueberries	33
Chinese cabbage	69	Soybeans	31
Mulberries	67		
Lentils	60	Dried beef	29
		Farina	29
Kale	58	Beet tops	29
Oat bread	58	Garlic salt	26
Goose	56	Gelatin	26
Okra	56	Chop suey	26
Rutabaga	54	Potato bread	26
Soybean bread	53	Tongue	24
Gooseberries	52	Parsnips	24
Huckleberries	51	Almond flavoring	22
Mustard greens	51	Salt pork	22
		Cracked grain	22
Pork butts	49	Youngberries	22
Popovers	49	Tangerines	22
Watercress	49	Sour cherries	22
Quince	46	Nut butter	21
Field corn	46	Limes	20
Ground lamb patties	44	Pimientos	20

fruits, desserts, spaghetti and macaroni, rye bread, peanuts, and margarine (see Table 4). In the Iowa group, 42% disliked lamb chops, as compared with 3% in the California sample. Some of the differences, such as the higher preference for desserts in the California group, may be due to the younger age level of the latter. Other foods listed in the Iowa study, such as ground beef, beef stew, pork chops, butter, sweet corn, white potatoes, lettuce, tomatoes, peas, celery, carrots, etc., gave very similar results in the California study.

Preferred methods of preparation. Under the conditions of this questionnaire, and taking into account the age and sex of the subjects interviewed, questions on methods of food preparation had a limited value. The food groups for which preparation preferences were most often given were vegetables and some meat and cheese dishes. Boiling was preferred for 35% of the 55 vegetables analyzed. The second choice was raw and/or in salad for 20% of the vegetables. These included cabbage, carrots, celery, cucumbers, endive, lettuce, onions, pimientos, radishes, tomatoes, and watercress.

TABLE 4
Comparison of foods rated very good and good in California and Iowa studies

	% [a] California	% [a] Iowa	% [a] Difference
Lamb chops	88	16	72
Margarine	48	6	42
Avocado	42	7	35
Figs	57	26	31
Apricots	87	60	27
Candy bars	87	61	26
Plums	75	50	25
Turkey	92	68	24
Grapes	90	66	24
Spinach	66	45	21
Macaroni	70	49	21
Spaghetti	84	64	20
Peanuts	85	66	19
Apples	88	69	19
Broccoli	31	13	18
Cake	91	73	18
Ice cream	97	81	16
Milk	84	68	16
Cookies	85	72	13
Rye bread	58	45	13
Pie	97	86	11
Bananas	96	85	11
Cabbage	50	87	37
Sauerkraut	41	62	21
Onions	58	77	19

[a] Percent of samples rated very good plus the percent rated good.

Artichokes and asparagus were preferred with mayonnaise; sweet potatoes, squash, and yams, baked; corn, boiled on the cob; eggplant, fried; peppers, stuffed; and potatoes, mashed.

The preferred method for macaroni was "with cheese"; for eggs, fried; for American cheese and cream cheese, in sandwiches; for cottage cheese, in salad; for ground meat, fried. Preferences for liver were divided between fried, and fried with onion.

Analysis of preferred menus. Breakfast. For this meal, a beverage was listed in 88% of the menus; fruit or fruit juice in about 60%; bread and pastry in 50%; eggs in 50%; meat in 40%; cereal in 40%; hot cakes and waffles in 30%; and accessory foods in 30%.

Milk, desired by about 50% of the questionees, was the most frequently mentioned beverage by both urban and rural boys for both weekdays and Sunday. About 20% requested coffee; 15%, chocolate or cocoa. The desire for a hot beverage was greater for this meal than for any other.

Fruit or fruit juice was designated by about two-thirds of the urban group for both weekdays and Sunday. A fairly large number of fruits was designated, oranges most frequently. A little less than one-half of the rural group wanted fruit or fruit juice for all breakfasts.

Eggs, and bread and pastry were listed by approximately two-thirds of the respondents for the weekday breakfast. These foods were listed by slightly more than one-third of the boys, for the Sunday menus. Eggs were designated most frequently as fried. A little over half mentioned toast as the bread and pastry item.

Meat was desired by about one-half of the urban group and one-third of the rural group for both weekdays and Sunday. Bacon was listed most frequently; ham was second choice.

Cereal was liked by about one-half of the rural and urban groups for weekdays. Only 20% of the urban group and one-third of the rural group listed it for Sunday. About one-third of the cereal choices was unspecified as to type, one-third was for some variety of ready-to-eat cereal, and one-third for a type of cooked cereal.

Waffles and pancakes were requested by around 50% for the Sunday menu; only about 15% listed these for weekdays. The most frequently mentioned accessory foods were fried potatoes, and syrup, jam, or jelly (on toast or hot cakes).

Lunch or noon meal. About 75% of the boys specified a beverage for this meal; dessert, 60%; sandwiches, 45%; meat, 30%; salad, 30%; potatoes, 25%; vegetables other than potatoes, 25%; bread and pastry, 20%; soup or appetizer, 10%.

Milk or milk shake was listed as the beverage by about two-thirds of the group for the weekday lunch and by about one-half for the Sunday noon meal. There was a somewhat larger percentage of requests for milk from the urban than from the rural boys. A wide variety of other drinks was requested.

The requests for dessert were very specific. About one-fourth of the desserts listed were combinations, such as cake, cookies, or ice cream with fruit; or cake, cookies, or pie with ice cream. Fruit ranked highest, followed by cake, ice cream, cookies, and pie. The most frequently mentioned fruit was apples. Of pies, apple was designated most often.

Sandwiches were listed by about two-thirds of the group for the weekday meal and by one-third for the Sunday meal. More urban than rural boys specified sandwiches. About 40% of the listings did not specify a particular type, about half specified meat of some type, and about 15% listed cheese.

Meat was requested more often for the noon meal on Sunday than on the weekday. For weekday lunches, hamburger or ground round was specified most frequently by the urban group, followed by chops and beef steak. Few in the rural group listed meat. On Sundays, roast was listed by the urban group, then cold meat. A large number of different meat dishes was requested by this group. Many of the rural group listed meat without specification, and about 15% desired poultry.

Salad was recorded somewhat more frequently for Sunday than for the weekday. The type was usually unspecified. Those most frequently mentioned were fruit, vegetable, lettuce, and lettuce and tomato, in that order.

Potatoes were desired more frequently on Sunday than on the weekday. Methods of preparation listed were mashed, with gravy, French fried or chips, and salad.

About 15% of the total group wanted one vegetable and about 10% listed two. About half of the urban group listed one vegetable for the Sunday noon meal. Peas were listed most frequently, followed by carrots and corn.

Bread was usually unspecified as to kind but "with butter" was noted. Rolls or biscuits were designated

by a few. Nearly all the requests under soup or appetizer were from the urban group, for soup for the Sunday noon meal. Fish and seafood were not listed.

Evening meal. For this meal, a beverage was desired by about 80% of the sample; dessert by 75%; meat by 70%; vegetables (not including potatoes) by 70%—40% listing one vegetable and 30%, two; potatoes by 60%; salad by 60%; bread and pastry by 30%; soup and appetizer, and accessory foods, by 20% each.

As with other meals, milk was by far the most popular beverage. Of those desiring a beverage, about three-fourths listed milk at this meal, with a slightly higher demand for the weekday dinner than for Sunday.

For the evening dessert, cake and pie were most frequently listed. Nearly as popular was ice cream either alone or with cake or pie. Fruit and pudding were listed fairly frequently. Fruit was often designated as canned or cooked, often peaches or apricots. A large number of other desserts was recorded. Combinations appeared about 10% of the time, as compared with 26% for the noon meal.

Of those listing a meat, about one-third designated "meat" for the weekday meal. Approximately one-fourth desired steak, with T-bone most frequently mentioned. Roast, usually beef, was recorded by a fifth of the respondents. About 10% listed chops. Meat was desired by about half of the boys for the Sunday evening meal. (The time for the main Sunday dinner ranged from noon to seven in the evening.) The type of meat dish desired was similar to the weekday evening meal with one exception, the requests for steaks and chops were about half those for the weekday dinner.

Green peas were the most popular vegetable, and were requested by about one-fifth of the respondents. Corn and carrots were close seconds. Spinach and string beans were also listed frequently.

Potatoes were recorded as such in about 50% of the menus. Where specified, mashed was most common. "With gravy" and French fried appeared several times. A large number of other dishes appeared once or twice.

Salad was most often listed as such (50%). Vegetable salad, most frequently tomato and lettuce, was designated by about one-quarter of the respondents. About 10% listed fruit salad.

Bread was requested by approximately one-third of the questionees. No single product was outstanding. About two-thirds wrote "with butter." The most common accessory foods listed were some type of paste or rice, pickles or relishes, and "left-overs."

Sandwiches, poultry, and fish and sea food were relatively unpopular for this meal. Soup was listed by about one-fifth of the subjects.

Typical menu. From an analysis of the foods given in the menus, a typical weekday's menu was assembled. The basis for selection was the most highly desired item in each food group which was listed by about one-third or more of the sample. Breakfast: milk, orange juice, toast (or hot cakes on Sunday), fried eggs, bacon, cereal. Lunch: milk, fruit and ice cream, two sandwiches, one meat and one cheese. Evening meal: milk, cake or pie, beef steak (roast on Sunday), mashed potatoes with gravy, salad, peas and either carrots or corn on the cob, bread with butter.

SUMMARY

The attitudes of 144 boys, 17 to 19 years of age, in northern California toward 258 foods and toward typical preferred menus were recorded by interview and questionnaire techniques.

A composite rating was worked out for each of the foods studied. The median was +89 (range +191 to —140), the highest possible rating +200, the lowest —200.

Fruits (especially bananas, strawberries, and pineapple), ice cream, pie, steaks, turkey, milk products, and butter had the highest ratings of the foods studied. Some vegetables (such as collards, dandelion, turnip, and beet greens, parsnips, rutabagas, kohlrabi, kale, escarole, and salsify), and organ meats, such as kidney and heart, red snapper, and buttermilk ranked lowest. Many of these latter foods had never been tasted or the names were not recognized by over half of the boys interviewed.

Buttermilk was disliked by 53% of the boys. Other highly disliked or unfamiliar foods are given in tables.

Information obtained from boys of this age group on the way they preferred the foods to be prepared was very scant.

An analysis of the preferred menus showed some trends. Milk was a highly desired beverage for all meals. Less than 10% of the boys requested coffee for lunch and dinner, a somewhat larger percentage for breakfast. A wide variety of desserts was desired for both lunch and dinner, often combinations of two or more. Steaks and chops appeared frequently on the weekday evening meal, while roasts were indicated for the Sunday dinner. Waffles and pancakes were desired for Sunday breakfast, eggs and toast for weekdays.

Acknowledgment

The author gratefully acknowledges the helpful suggestions of Dr. Agnes Fay Morgan and the assistance of Grace C. Beardsley in conducting the interviews and supervising the recording of information on the questionnaires. Preparation of the questionnaire and analysis of the data was done by the Quartermaster Food and Container Institute for the Armed Forces.

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Laboratory and Field Test Evaluation of the Methyl Ester of Alpha Naphthalene Acetic Acid as a Sprout Inhibitor for Potatoes[a,b]

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The effectiveness of the methyl ester of alpha naphthalene acetic acid for the control of sprouting and the extension of storage life of Quartermaster overseas shipments of white potatoes has been investigated. Conditions encountered under prevailing crating, stowing, and handling practices which were followed in the field tests greatly reduced the effectiveness of the sprout inhibitor.

Supplementary laboratory studies have also been made on treated and untreated potatoes stored at 40°, 72°, and 90° F. (4.5°, 22°, and 32° C., respectively). Observations have been made on changes in composition, rate of enzymic discoloration, utility, and palatability characteristics. The only temperature at which the inhibitor effected a significant reduction in sprout development was 72° F. Sprouting did not occur at 40° F. and was negligible at 90° F.

It has been reported that several millions of bushels of potatoes are lost every year as a result of sprout growth during storage. It is generally recognized that very little, if any, sprouting would occur if storage temperatures of 45° F. (7° C.) or lower could be maintained. However, not only are the facilities necessary for the maintenance of such low temperatures frequently not available throughout the long storage period, but certain disadvantages are effected by prolonged cold storage of potatoes. The accumulation of reducing sugars in potatoes stored at low temperatures makes them undesirable for use in the manufacture of dehydrated potatoes and potato chips, the high reducing sugar content being conducive to the formation of objectionable discoloration in these products; also, mashed potatoes prepared from the fresh product have been found to be unpalatable because of excessive sweetness and sogginess *(7)*. Consequently, it is necessary to "condition" such potatoes prior to dehydration or processing into chips. This is accomplished by storing them for several weeks prior to use, at temperatures above 70° F. (21° C.) during which a desugaring process occurs. However, when potatoes which have been in cold storage for several months are transferred to higher temperatures, they often sprout rapidly, resulting in considerable loss during the "conditioning" period. Obviously, some means for preventing or retarding sprouting in potatoes stored at higher temperatures was much to be desired.

With the development of growth inhibiting plant hormones, workers have been searching for a substance suitable for sprout inhibition of the potato tuber. Numerous chemicals, capable of inhibiting the growth of buds in potatoes and other vegetables, have been reported in the technical literature in recent years. The effectiveness of these materials has been found to be influenced by the time and manner of application, quantity of material employed, kind and variety of vegetable, and conditions of storage. Guthrie *(4, 5)*, Denny, Guthrie, and Thornton *(3)*, Denny *(2)*, and Thomas and Riker *(8)* have found the methyl ester of alpha naphthalene acetic acid to be the most satisfactory for retarding sprouts in potatoes. Experimental performance of this compound was sufficiently encouraging to result in the development of commercially available powders consisting of appropriate concentrations of the inhibitor in combination with an inert carrier. Treatment of tubers is accomplished by dusting them with these powders. Shredded paper and wax emulsions have also been used as carriers for the inhibitor.

The reports of losses of potatoes through sprouting from overseas shipments, coupled with the desirability of increasing the availability of fresh vegetables to troops in overseas areas, stimulated the interest of the Quartermaster Corps in the use of the inhibitor. Consequently, a series of tests was undertaken in the autumn of 1948, which included laboratory evaluation of treated and control lots of potatoes stored at various temperatures, as well as evaluation of performance of the inhibitor under actual shipping and overseas storage conditions.

The part of the study concerning the effect of the methyl ester of naphthalene acetic acid on the discoloration tendencies of the white potato, was designed to ascertain whether any relationship exists between sprout inhibition and the capacity of white potato tissue to form, by enzymic oxidation, darkly pigmented substances which are partially responsible for the discoloration of white potatoes.

MATERIALS AND METHODS

Potatoes used throughout the laboratory and field studies, except for the enzymic discoloration tests, were Idaho grown, U. S. No. 1, size A, Russet Burbanks from the late 1948 harvest. They ranged in size up to 18 ounces, with the majority falling in the 6 to 12 ounce range. At purchase, they were mature, firm, and contained less than 1% soft rot.

A commercial preparation containing 2.2% of the methyl ester of naphthalene acetic acid was utilized for applying the inhibitor as a dust. Application of the compound was at the rate of 0.153 lb. of dust, containing 1.52 g. of active material per 100 lb. of potatoes, as recommended by the manufacturer of the dust. This was slightly in excess of the amount the 1.14 g. inhibitor per 100 lb. of potatoes found effective by Denny *(2)*. Potatoes employed in the field tests were dusted in a commercial

[a] Presented at the Eleventh Annual Meeting of the IFT, New York, N. Y., June 19, 1951.

[b] This paper reports research undertaken at the Quartermaster Food and Container Institute for the Armed Forces, and has been assigned number 369 in the series of papers approved for publication. The views or conclusions contained in this report are those of the authors. They are not to be construed as necessarily reflecting the views or indorsements of the Department of Defense.

vegetable dusting machine. All lots, treated and untreated, were stored in wire-bound wooden crates, each containing 100 lb. of potatoes, net weight.

Potatoes used in the laboratory tests were treated by tumbling 50 lb. quantities in a large closed container with the prescribed amount of dust. Treated and untreated lots were stored in wire-bound wooden crates, each containing 100 lb. of potatoes. One-half of the potatoes from each crate was then packed in 5 cloth mesh bags, each containing approximately 10 lb. of potatoes. To each bag was affixed a tag carrying an identifying number and the net weight of the potatoes when placed in storage. Each set of 5 bags was placed in the center of the appropriate crate, and surrounded with the remaining 50 lb. of potatoes in bulk. This arrangement simplified the subsequent withdrawal of samples for evaluation. Treated and control potatoes were stored at 40° F. (4.5° C.), 72° F. (22° C.), and 90° F. (32° C.), and were sufficiently separated during storage to prevent any contact between the inhibitor-treated and the untreated potatoes.

Samples were wihdrawn from treated and untreated lots of potatoes at designated intervals. Because of the differences anticipated in the rate of deterioration of potatoes stored at different temperatures, the most frequent withdrawals were made from 90° F. storage, and the least frequent from 40° F. storage. Upon withdrawal, the entire contents of each bag were weighed and checked for sprouts and spoilage. Whenever sprouts had developed beyond the "peeper" stage, they were removed and weighed. Then 10 tubers from each lot were set aside for moisture and sugar analyses. The remainder of each sample, usually 6 to 8 tubers, was set aside for histological study. At less frequent intervals, additional 10-lb. samples were withdrawn from the bulk potatoes for preparational waste tests, and to provide material for taste panel evaluation.

Determination of reducing and non-reducing sugars. The tubers were washed under running cold water to remove adhering dirt and immediately wiped with a towel. When the skins were thoroughly dry, the potatoes were cut into strips and ground in a food chopper. The potato juice was expressed from the mash by pressing through a filter cloth in a Carver press, applying 10,400 lb. of pressure p.s.i.g. The juice was allowed to stand for 15 minutes to permit separation of the solids. The supernatant liquid was drawn off for reducing and non-reducing sugar assay. Appropriate tests indicated the absence of starch in the supernatant liquids from all samples. Then 25 ml. of the supernatant liquid was transferred to a 200 ml. volumetric flask containing approximately 150 ml. of distilled water. This was followed by the addition of 3 ml. or more when necessary, of a saturated solution of neutral lead acetate for clarification of the diluted juice, and additional distilled water to bring the total volume to 200 ml. The mixture was filtered through Whatman No. 12 filter paper and sufficient solid potassium oxalate added to the filtrate to precipitate all of the lead. Following removal of the lead oxalate by filtration through Whatman No. 3 paper, separate aliquots of the clear filtrate were taken for determination of reducing and non-reducing sugars. Reducing sugars were determined by the Munson-Walker gravimetric method *(1)* and calculated as mg. dextrose per 100 ml. of potato juice. Non-reducing sugars were determined by the same method following dilute acid inversion of the lead free filtrate. Appropriate corrections were made for the reducing sugar content, and non-reducing sugars were calculated as mg. sucrose per 100 ml. of potato juice.

Determination of enzymic discoloration activity. The potatoes used in this portion of the study were U. S. No. 1, washed, Idaho Russet potatoes, weighing approximately 10 ounces each. All were mature, firm, and in excellent condition at the beginning of the test. Three lots of potatoes, weighing 60 lb. per lot, were dusted by tumbling them in a large closed container with inhibitor dust containing 0.90 g. of active material. This was the same rate of application employed in the other laboratory tests. The potatoes were then packed loosely in a wooden crate. One lot was stored at each of 3 different temperatures, 40° F. (4.5° C.), 72° F. (22° C.), and 90° F. (32° C.). In addition, 1 crate of untreated potatoes, loosely packed, was stored at each of the 3 temperatures.

Samples of treated and untreated potatoes were withdrawn periodically and assayed for enzymic discoloration activity by a modification of the method of Wallerstein, Bergman, Byer, Alba, and Schade *(9)*. Eight potatoes, weighing approximately 5 lb., were selected at random, washed under cold running tap water, peeled with a stainless steel knife, and freed from all blemishes, scars, bruises, etc. The peeled potatoes were then placed in a large glass beaker under cold, running tap water. The outer portion of the peeled potatoes was cut away and the center portion saved. This represented approximately 30% of the whole potato. The center portion of each of the 8 potatoes was then cut into dice of approximately 1 cc., washed with cold running tap water, and then distilled water. The dice were kept in the refrigerator under distilled water until ready for use, usually within 30 minutes. At no time was any discoloration ever observed to occur within this short period.

The potato dice were then dried between sheets of filter paper and 100 g. taken for the test. These were placed in an aluminum Waring blendor container with 100 ml. of distilled water, and 5 ml. of pancreatic extract (one g. of U.S.P. pancreatin suspended in a mixture of 50 ml. distilled water and filtered through a cake of Filter-cel), and 3 drops of 1:1 ethyl acetate-caprylic alcohol mixture were added. The container was fitted with an aluminum screw cap with a hole in the center, through which was inserted a 2-way stopcock attached to a vacuum hose and to a source of nitrogen. The container was alternately evacuated and filled with nitrogen in order to permit maceration of the potato sample in an atmosphere containing a minimum of oxygen. The potatoes were macerated for 3 minutes at high speed, under a continuous flow of nitrogen. Blending was continued at low speed for approximately 1 minute to permit withdrawal of a uniform aliquot of the slurry. Then 40 g. of the white slurry were transferred into a 250 ml. Erlemeyer flask fitted with a glass stopper. Exactly 5 minutes from the beginning of the maceration period, the flask and contents were placed in a constant temperature water bath at 38° C. and shaken for 30 minutes at 114 oscillations per minute with a 3.2 cm. horizontal stroke. The flask was then removed from the bath, 200 mg. of Filter-cel added to the slurry and the entire mixture immediately filtered, by suction, through a cake of Filter-cel in a fritted glass funnel of coarse porosity. The filtrate was quickly transferred to an Evelyn tube and covered with a layer of mineral oil. The intensity of the color of the filtrate was measured in an Evelyn colorimeter at a wavelength of 420 mμ. The colorimeter was previously set at 100% transmittancy with distilled water. The manipulations involved were sufficiently rapid to permit color measurement exactly 5 minutes after removal of the slurry from the water bath.

RESULTS AND DISCUSSION

Laboratory tests. In the case of the potatoes stored at 40° F. and 90° F., differences in the general appearance and firmness of the treated and control samples from the same storage temperature proved to be so small as to be inconclusive. In Table 1 are illustrated the changes which occurred in the treated and untreated potatoes stored at various temperatures. During the first 13 weeks of storage, treated and untreated potatoes stored at 40° F. remained firm and showed no signs of sprouting. At the end of 17 weeks, about half of the untreated potatoes developed "peepers," that is, sprouts which did not exceed 1/16 inch in length, and showed evidence of slight dehydration. The treated potatoes, on the other hand, did not sprout at all and remained firm and unshriveled. Sprouts on potatoes stored at 90° F. were less than 0.5% of the total weight, but were no smaller on the treated lot than on the controls, indicating that the high temperature had been the growth retarding factor, rather than the inhibitor. The maximum sprout length in both cases was about 1/8 inch

after 13 weeks of storage. The potatoes were extensively shriveled and had a rubbery texture. Because of the generally poor condition of the potatoes, the 90° F. storage was concluded after 13 weeks.

Extensive sprouting occurred only at 72° F. and the inhibitor effected a significant reduction in sprout development at this temperature. During the first 13 weeks, the untreated potatoes grew sprouts up to 7 inches in length and resulted in a weight loss of 5.0%. Treament with the inhibitor resulted in the development of fewer and shorter sprouts, the maximum sprout length being 1 inch and the weight loss only 1.0%. At the end of 17 weeks, the maximum sprout length of the untreated potatoes was 9 inches and the loss in weight due to sprouting 8.7% whereas in the treated potatoes, the sprouts grew to a maximum of 2½ inches with a loss in weight of only 1.5%. Both treated and control lots became shriveled during storage but to a much lesser degree in the treated lot.

Considerable shrinkage occurred during the 13 week storage period in treated and untreated potatoes kept at 90° F., but this was due almost entirely to the change in moisture content. Loss of moisture varied with storage temperature and was significantly influenced by treatment with the inhibitor only at 72° F. At this temperature, not only did the inhibitor effect a reduction in losses due to sprouting but also in losses due to dehydration, as evidenced by the 22% dehydration loss in the untreated lot, and only 17% in the treated lot. The total loss, due to both sprouting and dehydration was indeed significant, being 31% in the control lot after 17 weeks of storage, compared with only 19% in the treated lot.

Although peeling and trimming waste measurements indicated a general trend towards increased waste with the progress of storage, no consistent differences were observed between treated lots and their controls, except in the case of potatoes stored at 72° F., the only temperature at which the inhibitor was effective. Percent peeling and trimming losses were calculated on the basis of the sprout-free tubers. It is conceivable that the smaller losses in the treated product may have been due to the reduced tendency toward dehydration as shown in Table 1.

TABLE 1

Influence of the sprout inhibitor on weight losses occurring in potatoes during storage at various temperatures

Storage temperature	Storage period	Sample	Weight loss			Maximum sprout length
			Due to change in moisture	Due to sprouting	Total	
			%	%	%	*inches*
40° F.	13 weeks	Control	3.2	0.0	3.2	.....
		Treated	3.9	0.0	3.9	.....
	17 weeks	Control	6.7	....[e]	6.7	<1/16
		Treated	3.7	0.0	3.7	.....
72° F.	13 weeks	Control	11.6	5.0	16.6	7
		Treated	10.8	1.0	11.8	1
	17 weeks	Control	22.2	8.7	30.9	9
		Treated	17.2	1.5	18.7	2½
90° F.	13 weeks	Control	19.4	0.3	19.7	⅛
		Treated	18.8	0.3	19.1	⅛

[e] "Peepers" not exceeding 1/16 inch in length.

Taste panel evaluation of the stored potatoes served in both mashed and baked forms, have failed to reveal any differences that could be ascribed to treatment with the inhibitor. Since it was only possible to test several samples at any one time, no attempt was made to compare the effect of storage temperature on the acceptability of the potatoes. Figure 1 indicates that there was

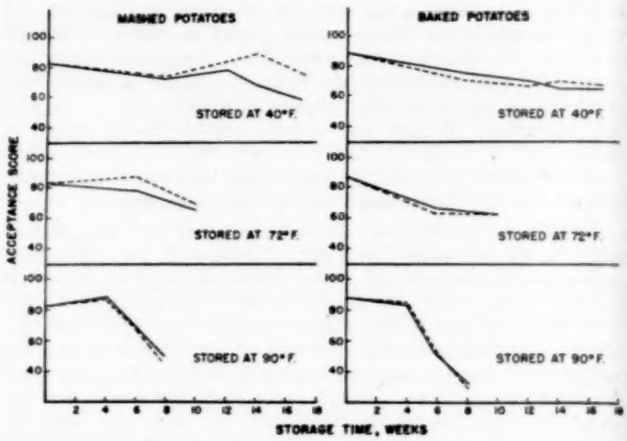

Figure 1. Effect of treatment with the inhibitor on the acceptability of potatoes. Solid lines indicate treated, dashes untreated samples.

a decline in the acceptability of the cooked products as the raw stock deteriorated with the progress of storage. This is especially evident in the instance of potatoes stored at 90° F. It may be observed that after 8 weeks of storage at 40° F., mashed potatoes from the untreated product received a higher acceptance score than did the treated product. It was found also that for some presently unexplained reason, the treated potatoes took up less water in cooking than did the untreated potatoes. The relationship between uptake of water and acceptability was indicated by the comments of a number of judges that the mashed potatoes from the treated lot were too dry. Addition of more milk to the treated sample to give it a consistency of normal mashed potatoes, resulted in an increase in acceptability to approximately the same level as that of the untreated mashed potatoes.

It has previously been reported that the methyl ester of naphthalene acetic acid has little, if any, effect on the sugar content of potatoes *(3)*. The findings obtained in our study confirm this view. Reducing sugar content of potato juice has been plotted against storage time in Figure 2. It will be noted that at each storage temperature the reducing sugar content of treated and control potatoes follow quite similar patterns. Temperature appears to be the dominant factor, and the samples from 40° F. storage were significantly higher in reducing sugar than those from either 72° F. or 90° F. The short lines branching downward from the principal graph lines to the right indicate the shift in reducing sugar content of samples of potatoes transferred from 40° F. to 72° F. for 4 weeks.

Figure 3 portrays the levels of non-reducing sugars in the storage samples. The concentrations encountered at 40° F. and 72° F. do not differ greatly, although there appears to be a slight upward trend near the end

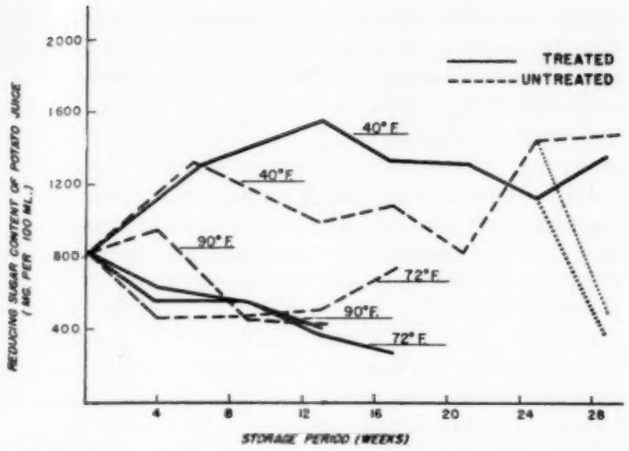

Figure 2. Influence of the sprout inhibitor on the reducing sugar content of potatoes stored at various temperatures. Solid lines indicate treated, dashes untreated samples.

of the 72° F. storage period covered by this chart. It should be noted that an increase in non-reducing sugars was encountered in the 90° F. samples. Although there was a tendency toward dehydration of the potatoes at this temperature, the reductions in moisture are by no means sufficient to explain the greatly increased concentration of non-reducing sugars. No attempt has been made to define the nature of the non-reducing sugars, but the large increase may possibly be explained by the formation of sucrose under the existing conditions of high storage temperature and dehydration. In an extensive investigation to determine the effects of tempera-

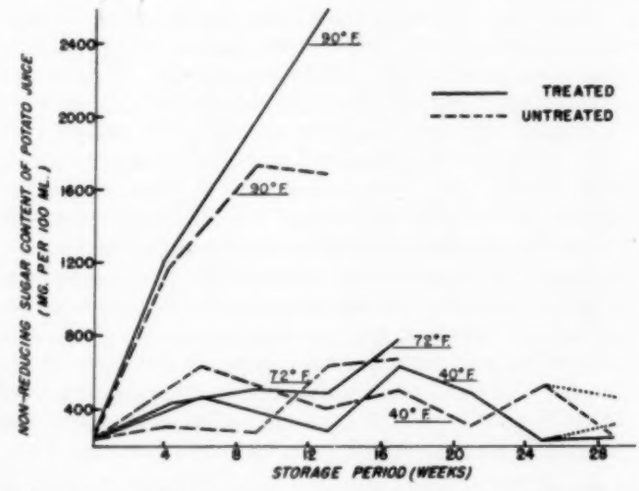

Figure 3. Influence of the sprout inhibitor on the non-reducing sugar content of potatoes stored at various temperatures. Solid lines indicate treated, dashes untreated samples.

ture and dehydration on the sugar content of potatoes, de Woolf *(10)* observed that the transformation of starch to sucrose was promoted by higher temperatures, and further stimulated by dehydration. It is interesting to note in this respect, that in acceptability tests conducted on potatoes stored for two months at 90° F., approximately half of the judges complained of excessive sweetness.

The results of the enzymic discoloration tests, illustrated in Figure 4, indicate that the treatment of white potatoes with the methyl ester of naphthalene acetic acid did not significantly influence the tendency of the potatoes to undergo enzymic discoloration. Storage temperatures seem to be the governing factor in such discoloration. Potatoes stored at 72° F. showed the greatest tendency to discolor, those stored at 90° F., the least. It is presumed that the 90° F. temperature tended to inactivate the enzyme or enzymes responsible for discoloration. Apparently the use of the sprout inhibitor to extend the storage life of potatoes prior to processing would not have any deleterious effects on the appearance of the processed product.

The histological studies are not discussed here since they will be reported in another paper. However, it can

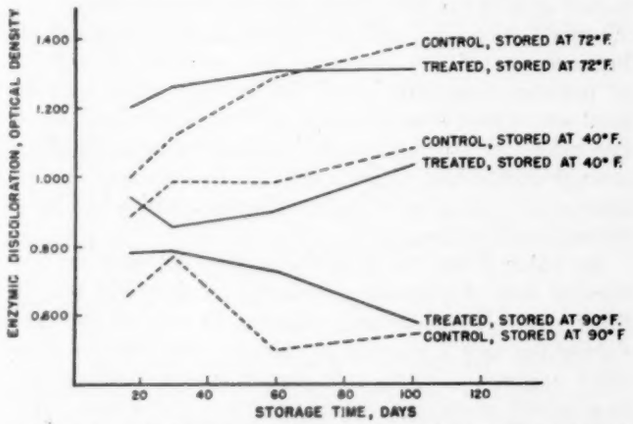

Figure 4. Influence of storage temperature and treatment with the sprout inhibitor on the tendency of potatoes to undergo enzymic discoloration. Solid lines indicate treated, dashes untreated samples.

be stated that changes which can be related to treatment with the inhibitor have been found in bud tissue structure.

Field test. The 18,000 lb. of potatoes used in the field test were procured through regular Army channels, repacked, stored, and shipped to points of consumption by means as comparable as possible to routine supply procedure. The major deviation from routine practice, aside from the actual experimental treatments under study, was the procurement of freshly harvested potatoes in the fall. Normally, potatoes for consumption in the spring would be procured from commercial stocks shortly before use, thereby placing the burden of warehousing on suppliers. Procurement of the potatoes in the fall permitted the treatment of one lot shortly after harvest, which in practice would be the most convenient time for treatment and would eliminate extra handling during the storage period. A comparable lot was treated 3½ months later, shortly before removal from controlled temperature storage. This procedure afforded an opportunity to obtain information on the importance of time of application on the effectiveness of the inhibitor. A third lot, serving as control, remained untreated.

The potatoes were kept in cold storage in Seattle, Washington from the time of procurement until the time of shipment to their Alaskan destination. All lots held up satisfactorily during storage at Seattle and shipment to Alaska. The transfer from Seattle to Whittier,

Alaska was made by refrigerated ship; from Whittier they were transported by refrigerated railroad car and truck to Fort Richardson and placed in a root cellar for storage. The time elapsed between purchase of potatoes and their arrival at Fort Richardson was 6 months. During this entire period the temperature of storage was in the vicinity of 40° F. Temperature records were maintained throughout the test by the use of recording thermometers.

The root cellar temperature during the first month of storage ranged from 38° to 42° F., while external temperature ranged from 50° to 60° F. It soon became apparent that the seasonal peak temperature would not be reached in the root cellar during the experimental period despite the increasing external temperatures. To stimulate sprouting, and to provide a good comparison between treated and untreated lots, one-half of each lot of potatoes was transferred for storage to an outside shed where they would be exposed to temperatures more favorable for sprouting, and which would simulate storage conditions which might be encountered in the absence of root cellar storage, a situation which had been experienced in the past.

In Table 2 the effect of the sprout inhibitor on the various lots of potatoes employed in the field test is illustrated. No sprouting occurred in any of the lots during the first 7 months of storage when the potatoes were exposed only to cold temperatures. During the final month of storage, the temperature of the root cellar rose gradually to a maximum of 56° F., while the outside temperature fluctuated between a low of 52° F. and a high of 73° F. Under these conditions, sprouting occurred in all lots, though to a far greater extent in the potatoes exposed to the higher outside temperatures. However, only small differences were observed which could be attributed to treatment with the inhibitor. Pre-storage treatment with the inhibitor proved to be of no advantage over later treatment. Under field conditions, temperatures in the vicinity of 40° F. were found to be much more effective in retarding sprouting than use of the sprout inhibitor. Treatment of potatoes had no measurable effect on reduction of shrinkage, rot, or preparational wastes under conditions of this study. Losses resulting from changes in moisture throughout the 8 month storage period were the same in all cases, approximately 6%.

In consumer-type acceptability tests to determine the effects of treatment by the sprout inhibitor on the cooked product, 59 men were selected at random from the personnel eating in the dining halls at Fort Richardson. All lots were tested as baked and mashed potatoes, prepared according to specified recipes and directions. The potatoes were served as a component of the regular menu and only one lot, prepared either as mashed or baked potatoes, was served at a meal. Judges were supplied with questionnaires and asked to check the desirable and undesirable characteristics pertinent in explaining their judgment of the test sample. The results of the consumer type tests indicated that neither treatment with the sprout inhibitor nor method of storage at Fort Richardson effected any significant differences in the acceptability of potatoes when served in either mashed or baked form.

Although the laboratory studies demonstrated the effectiveness of the sprout inhibitor at 72° F., inhibition was not complete since sprouting did occur, although less vigorously, in the treated potatoes as well as in the untreated potatoes. The inhibitor proved to be of no benefit at 90° F., since appreciable sprouting did not occur at this temperature even in untreated potatoes, nor did the inhibitor appear to affect dehydration or other types of deterioration. Under field conditions, the results were somewhat disappointing for little difference in sprouting, attributable to treatment with the inhibitor, could be demonstrated in any of the lots. Temperature again was the dominant factor. At the lower temperatures encountered, in the vicinity of 40° F., none of the potatoes sprouted; at higher temperatures all lots sprouted, with maximum sprouting occurring at temperatures in the vicinity of 70° F.

A number of factors may have contributed to the relative ineffectiveness of the compound. First of all, considerable ventilation existed in storage. This would tend to volatilize and dissipate the inhibitor. Secondly, some difficulty was encountered with poor adhesion of the dust to the potatoes, and it is likely that a considerable portion may have been shaken from the tubers during the loading, unloading, and shipping operations. A further partial explanation may be in the fact that the potatoes were unwashed. Luckwill *(6)* has reported that the presence of soil may render the inhibitor ineffective, although no explanation has been offered regarding the mechanism involved. It has been shown in this and other studies that under carefully controlled conditions, the methyl ester of naphthalene acetic acid is an effective sprout inhibitor for white potatoes. How-

TABLE 2
Effect of sprout inhibitor on potatoes under Armed Forces conditions of use

Storage conditions	6 months under refrigeration, 1 month in root cellar [d]			6 months under refrigeration, 2 months in root cellar [e]			6 months under refrigeration, 1 month in root cellar, 1 month in outside shed [f]		
Sample	Control	Treated prior to storage	Treated after 3½ months' storage	Control	Treated prior to storage	Treated after 3½ months' storage	Control	Treated prior to storage	Treated after 3½ months' storage
Potatoes containing sprouts,[g] %	0	0	0	100	100	99.1	100	100	100
Sprout weight, % of total weight	---	---	---	0.91	0.87	0.60	2.9	2.3	2.4
Sprout length, inches	---	---	---	⅛-5½	⅛-5¼	⅛-4	⅛-11	⅛-9½	⅛-9

[d] Temperature in root cellar during this period was 40° F. ± 2°.
[e] Temperature during first month was 40° F. ± 2°; rose gradually during second month up to a maximum of 56° F.
[f] Temperature in outside shed ranged from 52° F. to 73° F.
[g] Does not include sprouts less than ⅛ inch in length.

ever, because of the limited conditions under which the inhibitor can exert its maximum influence, and because of the impracticability of handling Quartermaster shipments within these limits, it has been concluded that treatment of the potatoes with the inhibitor offers no realizable advantages.

Acknowledgments

The authors gratefully acknowledge the cooperation of the firm of Mitchell, Lewis and Staver, of Portland, Oregon, who supplied the vegetable dusting machine used in these tests, and of the Quartermaster Market Center for arranging the procurement and overseas shipment of the test samples.

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Clarification of Wine by a Sequestering Agent[a,b]

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(Manuscript received May 15, 1950)

The causes of turbidity in wines due to iron have been discussed by many investigators, and in most cases it is believed due to the formation of ferric iron complexes with phosphates, tannin, and other organic colloids of wine, causing a suspension as a haze or cloud. The iron in solution is present first as the ferrous ion, which usually does not cause a precipitation, and which upon standing may be oxidized to the ferric or trivalent form. Ferric compounds causing white "casse" have a tendency to disappear when exposed to light and to reappear upon standing in the dark. Weil *(7)* explains this photochemical reaction as due to the reduction of ferric compounds to ferrous compounds under the influence of light.

A number of years after it was discovered that iron caused cloudiness, copper was also found to be a constituent of turbidity in white wines. It was found that the cuprous ion in wines caused the formation of a colloidal precipitate. Sufficient oxygen is present during filtration and bottling to keep the copper in the cupric form, and upon standing the oxygen may combine with the wine, and reducing materials, such as SO_2, may then reduce the copper to the cuprous condition with the resultant formation of a precipitate.

Numerous methods have been devised for clarification of wine. The usual fining agents for wine are gelatin, tannin, casein, isinglass, and bentonites. The effectiveness of these clarifying agents in removing iron depends on how much of the iron is in the ferric condition. Apparently there is no direct combination of the iron with the clarifying agents; instead, they act by combining with, or by electrically precipitating, the ferric complex compounds. Other methods of clarification have included such materials as skimmed milk, blood, eggs, sawdust, soybeans, ground white mustard, and wheat bran.

Today the most practicable treatment in Europe for both iron and copper "casse" is with potassium ferrocyanide, known as blue-fining. Potassium ferrocyanide combines with iron and copper ions to form a heavy insoluble precipitate which may be removed by filtration. There is considerable controversy over this method of treatment, according to Fessler *(1)* mainly because the addition of potassium ferrocyanide to wines provides opportunity, as a result of hydrolysis of the ferrocyanogen radical, for the formation of hydrocyanic acid, a well-known deadly poison.

It is believed that chelating or sequestering agents provide a more suitable answer to the problem of metal "casse" in wines by de-ionizing the divalent and trivalent ions and forming stable, soluble complexes that are non-toxic. Two such methods, using polyphosphates, have been reported by Geigey *(2)* and Libbey *(3)*. The present paper reports the results obtained in a study of the clarification of wine by the sequestering agent "Sequestrene," representing the mixed sodium salts of ethylenediamine tetraacetic acid.[c] Sequestrene was regarded as a representative of various commercially available chelating or sequestering agents and although no experiments were performed with other similar products, it is likely that similar effects may be obtained by such agents other than the one applied in these tests. For brevity's sake, the compound used will be designated by its trade name throughout this paper.

[a] Presented at the Ninth Annual Meeting of the IFT, San Francisco, California, July 14, 1949.
[b] Contribution No. 829, Massachusetts Agricultural Experiment Station.
[c] Present address: Oscar Mayer and Co., Madison, Wisconsin.

[c] Manufactured by the Alrose Chemical Company, Providence, R. I.

EXPERIMENTAL PROCEDURE

To secure information on the effect of Sequestrene on iron and copper casse in white wines, both laboratory and commercially produced cloudiness were treated with various amounts of Sequestrene. Storage tests and taste panels were also conducted to determine any adverse effects.

Laboratory development of iron and copper casse. Iron cloudiness was introduced into various commercial white port and Sauterne wines by adding the ferric ion as ferric chloride. Known amounts of a 1% ferric chloride solution were added to give from 10 to 100 p.p.m. of the ferric ion in the wines. The difficulty of placing the cuprous ion in wines to cause cloudiness was overcome by two procedures. Known amounts of a 1% cupric chloride solution were pipetted into Sauterne and white port wines and nitrogen bubbled through the wines for about 3 minutes. The bottles were then tightly corked and allowed to stand 1 week. A second way consisted of placing an excess of cuprous chloride in contact with the wine for about a day, and filtering and bubbling nitrogen through the samples. These were set aside for 1 week. Bubbling nitrogen through the wines removed most of the included oxygen and allowed reducing materials in the wine to reduce the copper to the cuprous ion. Heavy sediment was noticed with both iron- and copper-induced cloudiness in these wines.

Clarification. Since 6.7 and 5.9 parts of Sequestrene are the theoretical quantities needed to combine with 1 part of iron and copper, respectively (mol. wt. of Sequestrene is 372), these and various other amounts were added to the clouded wines to determine the most practical amount to use. The process of clarification by Sequestrene was followed with a spectrophotometer (Coleman Junior—Model 6A). It was possible to notice changes in both turbidity and color by this method.

Sequestrene may be added to wine as an aqueous solution or in the solid state. The solubility of Sequestrene is approximately 10% in water, giving a pH of 5.

Commercial iron and copper casse. Samples of commercial iron and copper cloudiness were obtained through the Berkeley Yeast Laboratory, Berkeley, California. The amount of iron present in these samples of cloudy wines was ascertained by following the *o*-phenanthroline method of Saywell and Cunningham *(5)*. Copper determinations were made by the Marsh procedure *(4)*, a very satisfactory, quick method. Here 8 parts of Sequestrene were then added for every 1 part of iron or copper found in the troubled wines, and clarification noted.

RESULTS

A typical, graphical result of clarification by Sequestrene of various wines experimented with is given (Figure 1). The white port wine shown here contained 100 p.p.m. of ferric ion, far in excess of that normally found in cloudy wines. Various amounts of Sequestrene were added, including quantities above and below the theoretical amount needed to clear the wine. The graph shows it takes between 5 and 10 hours for clarification to take place, depending on the amount of Sequestrene present. The more Sequestrene added, the faster the clarification. The most practical amount of Sequestrene was found to be about 8 times the amounts of either iron or copper present in cloudy wines. It will be noted there is a difference in the percent transmission of light between the original clear wine and the clarified wine. This difference is due almost entirely to the color that iron imparts to the wine. The solution of Sequestrene added to the wine imparted no color. The smaller the amount of iron the wine contained, the smaller the difference in color.

The effect of light and darkness on clarification time of wine containing iron is represented in Figure 2.

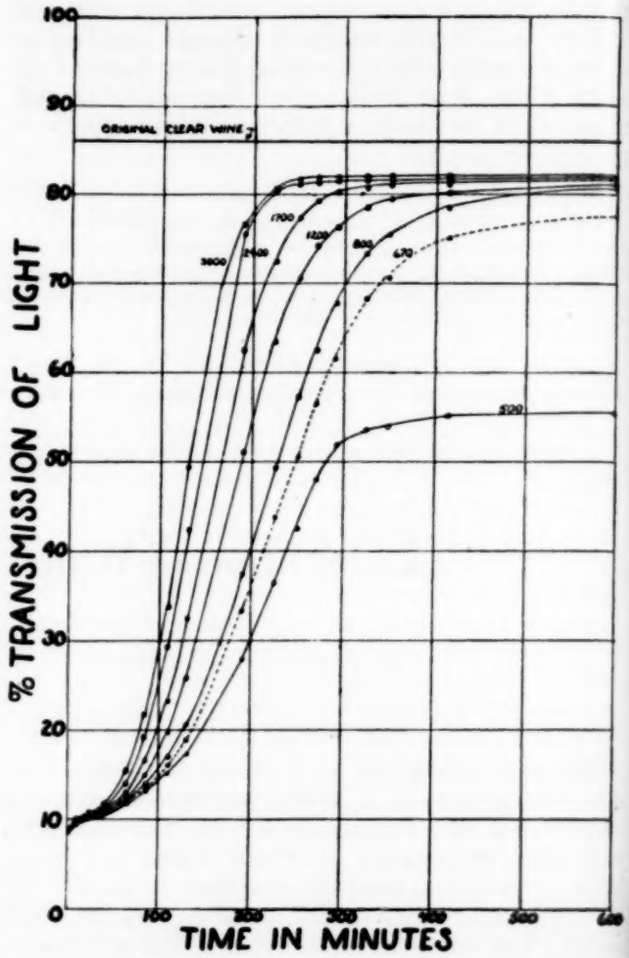

Figure 1. Clarification of port wine containing 100 p.p.m. ferric ions by Sequestrene. Action of calculated amount of agent indicated by dotted line while the p.p.m. of Sequestrene used in the various tests is given alongside the curves. The turbidity is indicated by the percent transmission at 450 mμ.

Samples of wine containing 25, 50, and 100 p.p.m. of iron were held in light and darkness after the addition of Sequestrene (8 times the amount of iron) and the process of clarification followed. As mentioned previously, according to Weil *(6)*, light speeds up the disappearance of ferric casse. Eventually, those held in the dark were clarified to the same point as those held in the light. This difference in time was not noted in the clarification of copper casse.

Two samples each of commercial copper and iron casse were similarly clarified with Sequestrene. Clarification of these commercial samples took between 10 and 15 hours. This may have been due to a more stable formation of the iron or copper complexes than those found in laboratory-produced cloudiness.

Actual clarification taking place is shown in Figure 3. At the beginning of the experiment (zero hr.) both samples, A and B, contained 50 p.p.m. of ferric iron, which formed a very heavy sediment; 400 p.p.m. of Sequestrene were added to Bottle B. The photographs show complete clarification in five hours. A comparison between the clarified wine (B) and the original clear wine (bottle at left) is shown in Figure 4.

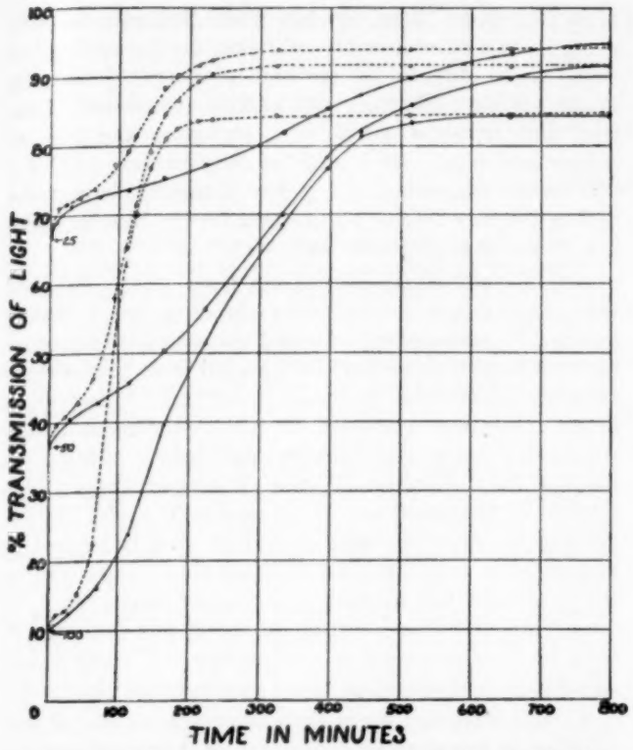

Figure 2. Effect of light and darkness on the clarification of white port wine. The ferric ion contents of the wines is given in p.p.m. alongside the curves, the amount of Sequestrene used was 8 times the amount of iron. Solid lines: held in darkness; dotted lines: held in light.

Storage Tests

Since wine is known to have a long shelf-life, it was essential to clarify and store the various wines for a period of time, to see if the agent possesses the property of stability, among its other properties. At the time of this writing, 6 months had passed since the beginning of the storage period. Upon examination of the stored samples of Sauterne and white port wines, no noticeable formation of sediment had taken place, nor had the Sequestrene affected the taste. From previous experience, it is known that Sequestrene is highly stable for very long periods of time, over a fairly wide range of pH and temperature.

Taste Panels

Taste panels of 20 to 25 graduate students and faculty were conducted on different wines containing various amounts of Sequestrene, to ascertain if Sequestrene introduces any unfavorable characteristics.

It was decided to test the sensitivity and imagination of each individual, in order to have a carefully selected panel. Four wine bottles, lettered A, B, C, and D, were filled with the same wine. Sample A was designated as the control, scored perfect, and used for comparison purposes only. Those scoring Samples B, C, or D considerably lower than A were eliminated from future panels. Other panels were conducted in the same manner, i.e., Sample A was previously scored as perfect and used as the control and for comparison. Sample A consisted of the same wine as found in Bottles B, C, and D,

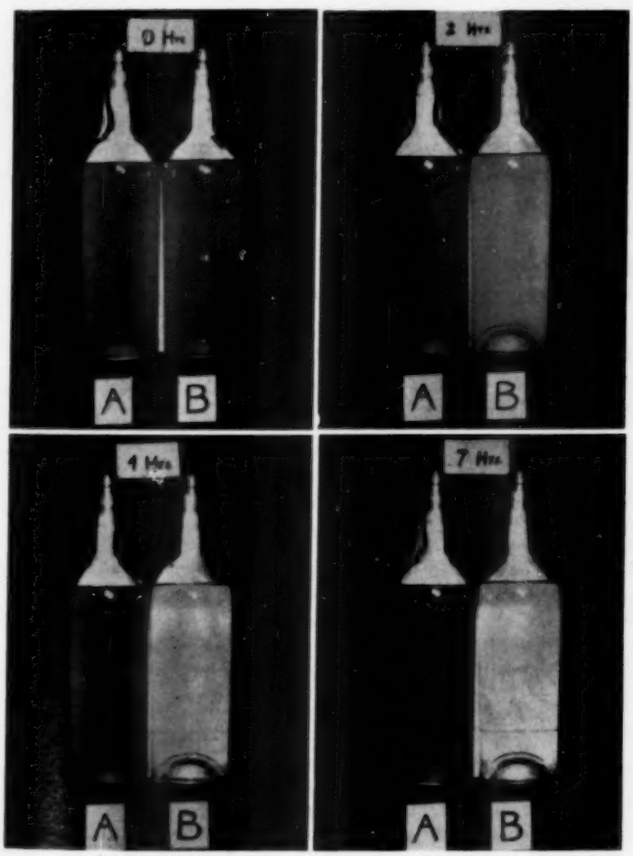

Figure 3. Clarification of a wine containing 50 p.p.m. ferric iron. Sample A: no addition; sample B: 400 p.p.m. Sequestrene added.

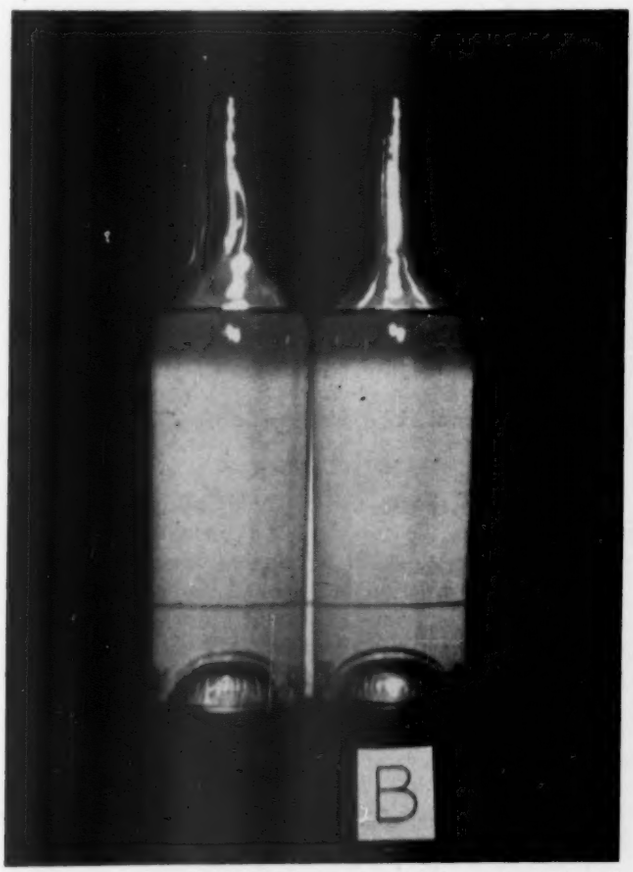

Figure 4. Comparison between the clarified wine (B) and the original clear wine (bottle at left).

except no Sequestrene was added to it. Also, in each panel, one other sample, either B, C, or D, contained no Sequestrene. This was done to eliminate those using their imagination. Six panels were conducted with various wines containing from 250 to 2,000 p.p.m. of Sequestrene. No adverse effects as to appearance, taste, or bouquet were bestowed to the wine. The taste of Sequestrene is only slightly noticeable even in a 1% aqueous solution.

Toxicological Investigation

Anyone interested in adding new materials to foods should be concerned with the toxicity of the material. Both acute and chronic toxicological experiments were conducted on laboratory animals. Single oral doses as high as 4,000 mg./g. of body weight were administered to albino rats with no noticeable toxic manifestations occurring. This would correspond to giving more than one-half pound to a person of average weight (70 kg.). It was impossible to administer higher doses to the rats because of the size of a rat's stomach and the solubility of Sequestrene. Long-time feeding experiments were carried on for a period of 1 year. Two groups of weanling albino rats were started on a basal ration of Purina Fox Chow for a 7-day period. At the end of that time 1 group was offered the basal ration plus 0.5% of the Sequestrene by weight. The other group was used as the control and fed only the basal ration. Food and water were supplied on ad libitum bases for both groups. Analysis of the individual feed intake, weight records, and observation for a period of a year showed no abnormal changes in activity, appetite, and gross appearance, or other abnormal manifestations. The animals were killed and autopsied at the end of the feeding period and a pathological examination of the organs showed no abnormalities.

Long time feeding tests still under way (1952) at the Nutrition Laboratory of the Department of Food Technology at the University of Massachusetts, show no indication of chronic toxicity. It should be understood that further tests may be required to satisfy completely present-day requirements for the non-toxicity of a chemical additive to a food product. It is also suggested that prospective users of the method described in this paper ascertain the possible limitations which may be placed upon the use of sequestering agents in foods under the Federal Food, Drugs and Cosmetics Acts.

DISCUSSION

The presence of iron and copper has caused considerable trouble in the formation of metal cloudiness in wines and other alcoholic beverages. The clouding is a result of the formation of colloidal suspensions of insoluble ferric compounds on oxidation or of insoluble copper complexes on reduction. Numerous investigators have suggested and found various methods for remedying this trouble. Treatment with potassium ferrocyanide as used today and permitted under Federal regulations is the most reliable method of removal of excess iron and other heavy metals; however, it must be used with close, chemical control to prevent formation of prussic acid, a powerful poison.

Results given here indicate that Sequestrene may prove to be a more suitable substance for the removal of metal casse, due to its unusual property of forming stable, soluble complexes with certain monovalent, divalent, and trivalent metal ions, including the ions of copper and iron. As 1 mole of Sequestrene (372 g.) will bind a maximum of 1 g. ion of metal, Sequestrene is thus a more effective sequestrant for the heavier metal ions than for the lighter ones.

Actual commercial procedures have yet to be tried with Sequestrene for checking clouding due to heavy metals. Experiments performed show that wines troubled with metal casse may be clarified with Sequestrene after the cloudiness or haze is formed. However, a better procedure would be to add Sequestrene to the wine after fining and filtering and before bottling, to prevent the formation of iron or copper casse. This method of treatment would be especially useful in preventing the type of metal cloudiness that is formed in bottled wine upon standing for some time. This is often the case with the formation of copper casse, since its presence is not found during filtration and bottling. It must be remembered that Sequestrene will control only metal casse and not other types of non-metal cloudiness.

Taste panels and short-time storage tests reveal that addition of Sequestrene does not impart any unfavorable characteristics to white wines. Toxicological feeding tests seem to indicate that Sequestrene is non-toxic in a range far above the amount that would be used for clarification purposes.

SUMMARY

Based on data obtained from the clarification of several metal-cloudy wines, the disodium salt of ethylenediamine-tetraacetic acid, combines with heavy metals to form soluble complexes of high stability. It should be added at the rate of 8 times the amount of iron or copper present, to obtain the best results in clarifying or preventing metal cloudiness. Clarification normally takes place in 5 to 10 hours after the addition of Sequestrene, which may be added as a solid or an aqueous solution.

Other experiments show that Sequestrene imparts no unfavorable characteristics to wine even after storage, and further evidence indicates that it is non-toxic for use as a clarifier.

Acknowledgment

The authors wish to express their appreciation to The Alrose Chemical Company of Providence, Rhode Island, for the fellowship which made possible the studies reported herein.

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Growth of Food Yeasts in Olive Residue Hydrolysate

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Olive residue may be effectively used as a medium for growing food yeasts. The neutralized olive residue hydrolysate as a carbon source plus some growth factors served in our study as a good medium for growing several genera of yeasts. Approximately 80% of the reducing sugar was utilized and converted to protein. In general, 5% of the dry olive residue was converted to protein.

In making edible olive oil, the ripe olives are ground, and exposed to pressures of 1000 to 1500 lb. p.s.i.g. for the first pressing. The resultant paste is either rinsed with hot water or reground and pressed for a second time at pressures of 1500 to 2000 lb. p.s.i.g. The olives so treated still contain about 8 to 10% oil, which is extracted with solvents until the pomace contains less than 0.5% oil. The other constituents of this pomace are: cellulose, 29-30%; pentosans, 7-8%; protein, 6.5%; ash, 2.5-3%; moisture, 6.5%; reducing material such as glucose, 0.6%; lignin and non-extractables amounting to about 40%.

In the Mediterranean basin, approximately 2 million tons of this residue are produced annually. At the present time, this by-product is used principally as fuel. Other uses suggested or employed to a very limited degree are: formation of acetic acid and methanol by destructive distillation *(9)*; fertilizer *(6)*; paper cellulose *(8, 3)*; charcoal production *(10)*; and natural alcohol fermentation to form 3% alcohol *(9, 7)*. The purpose of this particular investigation is an attempt to find additional industrial uses for the olive residue, specifically, to determine optimum conditions for its use for producing yeasts of high nutritional value.

EXPERIMENTAL PROCEDURES

Hydrolysis. Various preliminary methods were employed, but the conditions adopted were as follows: The olive residue was pulverized in an electric blender and hydrolyzed with 3.5% sulfuric acid, using 5 parts of liquid to 1 part of residue, at a temperature of 120° C. for 3 hours. The hydrolysate consisted of 2 successive acid extractions of the olive residue. From 100 g. of olive residue we obtained about 18 g. of reducing sugar, calculated as glucose. The combined acid hydrolysates were neutralized with anhydrous $CaCO_3$ by intermittent boiling and filtration. It was found that 2-3 g. of $CaCO_3$ per gram of reducing sugar were necessary to bring the pH up to 5.0. This neutralization procedure decreased the reducing materials to about 14%, calculated as glucose.

Selection of the organisms. Many species and genera of yeasts were screened upon an olive hydrolysate agar, consisting of hydrolysate, 100 ml.; $(NH_4)_2SO_4$, 0.3 g.; KH_2PO_4, 0.3 g.; yeast extract, 0.3 g.; and agar, 1.5 g. This medium contained about 2.6% reducing sugar and had a pH of 5.1. Only a few of the many yeasts examined grew well on this medium: namely, *Saccharomyces carlsbergensis* ATC 9080, *Pichia membranaefaciens* ATC 2254, *Torulopsis utilis* ATC 9950, *Candida krusei* Y 1736, and *Geotrichum species* IIT 79.

Propagation of organisms. The cells were produced by growing the yeast in a shaker flask at 28° C. for 72 hours. To a 125 ml. Erlenmeyer shaker flask were added (a) 50 ml. of a medium, (initial pH 5.2) consisting of neutralized hydrolysate, salts, nutrient adjuncts, with a total reducing sugar content of 1.5% to 2%; and (b) an inoculum, of 6 to 150 $\times$ 10^6 cells of yeast culture which had been grown upon an olive hydrolysate agar slant.

Experimental media. The following combinations of nutrients and salts have been used:

Medium A.
Hydrolysate 100 ml.
Total reducing sugar 1.38 g. Inital pH 5.2.

Medium B.
Hydrolysate, 100 ml.; urea, 0.5 g.; KH_2PO_4, 0.5 g.
Total reducing sugar 1.38 g. Initial pH 5.2.

Medium C.
Hydrolysate, 100 ml.; malt extract, 1.0 g.
Total reducing sugar 1.85 g. Initial pH 5.3.

Medium D.
Hydrolysate, 100 ml.; malt extract, 1.0 g.; yeast extract, 1.0 g.
Total reducing sugar 1.85 g. Initial pH 5.2.

Medium E.
Hydrolysate 100 ml., 0.5 g. $(NH_4)_2SO_4$, 0.5 g. KH_2PO_4.
Reducing sugar 1.38 g. Initial pH 5.2.

Medium F.
Hydrolysate 100 ml., 0.1 g. urea, 0.5 g. KH_2PO_4.
Reducing sugar 1.38 g. Initial pH 5.6.

Medium G.
Hydrolysate 100 ml., 0.5 g. malt extract, 0.5 g. yeast extract.
Reducing sugar 1.54 g. Initial pH 5.2.

Medium H.
Glucose 1.26%, peptone 0.5%, yeast extract 0.3%, $NaNH_4HPO_4$ 0.5%, KH_2PO_4 1.0%. Initial pH 6.2.

Quantitative analysis. The cell crop for all the yeasts studied except *Geotrichum* was determined with a Levy counting chamber because the hydrolysate medium contained a precipitate which was formed during the sterilization and propagation periods. *Geotrichum* was evaluated by determining the nitrogen content and translating this to protein present since *Geotrichum* formed an extensive mycelium.

For the nitrogen determination the microkjeldahl method was used on the dried cells as well as on the dried precipitate when necessary. In the latter case, the nitrogen of the precipitate was subtracted, to give the content of nitrogen in the yeast cells. Sugar was determined by the Shaeffer-Somogyi method. The cells were dried in a vacuum oven at 40° to 45° C. under 30 inches of vacuum for 15 to 20 hours.

RESULTS AND DISCUSSION

Torulopsis utilis had a considerably greater production of cells in the medium in which the nutrient adjuncts were malt extract and yeast extract rather than malt extract alone, as indicated in Figure 1. Urea did not effectively serve as a nitrogen source. Yeast extract or malt extract when used separately as a nutrient source gave approximately the same yield of yeast, namely 400 $\times$ 10^6 cells per ml.

In the experiments with *Pichia membranaefaciens*, the nutrient malt extract did not give any better growth than urea. On the contrary the use of yeast extract

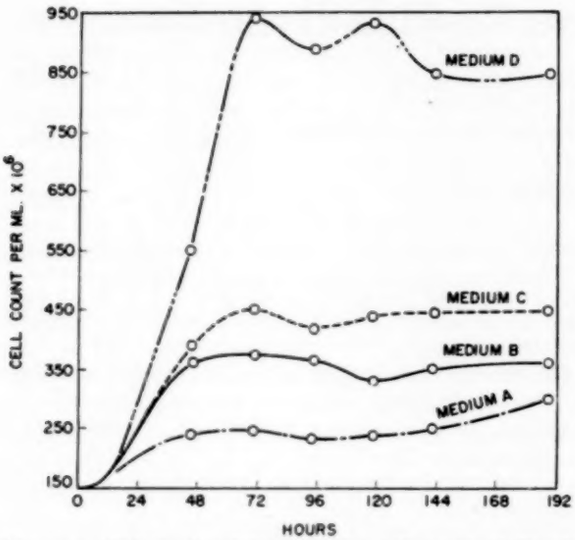

Figure 1. Effect of nutrients on the cell count of Torulopsis utilis.

alone or in combination with malt extract produced a remarkable increase in the number of cells formed, as may be observed in Figure 2. The yeast extract alone gave a cell count of 700 × 10^6 per ml. Thus, it may be said that the nutrient yeast extract is more effective as a growth factor than the malt extract with reference to *Pichia.*

The results for *Saccharomyces carlsbergensis* shown in Figure 3, and for *Candida krusei* shown in Table 1, indicate that the significant growth occurs when malt extract is added. The addition of yeast extract to the malt extract medium did not increase the yield. It should, also, be noted that the addition of urea did not enhance the growth of *C. krusei* or *S. carlsbergensis* over that attained in the olive residue substrate. Furthermore, the growth of *Candida* and *Saccharomyces* was much less than that for *Torulopsis* and *Pichia.*

Either yeast extract or malt extract provided good growth conditions for *Torulopsis utilis.* The amount

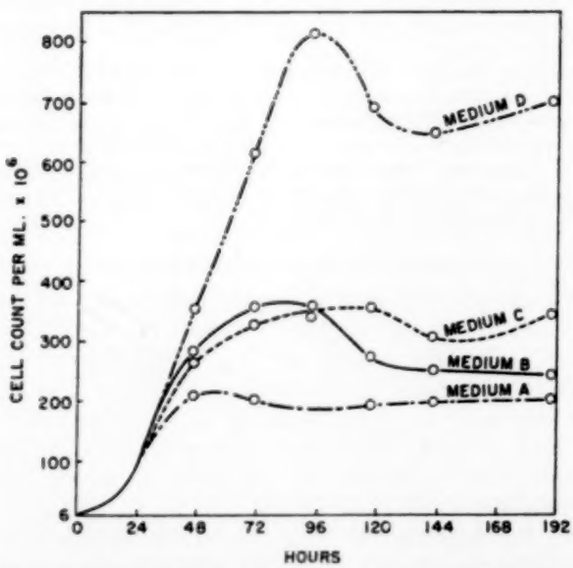

Figure 2. The effect of nutrients on cell count of Pichia membranaefaciens.

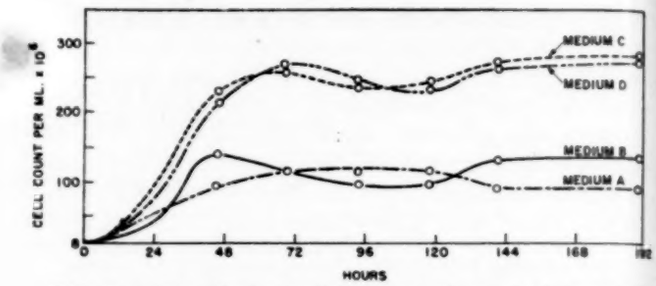

Figure 3. The effect of nutrients on cell count of Saccharomyces carlsbergensis.

of growth was proportional to the quantity of adjunct added (1% of both gave approximately double the growth obtained for 1% of either alone). In these hydrolysate media, yeast extract only provided the necessary growth factors for *Pichia membranaefaciens* and malt extract was necessary for introducing the growth factors, for *Saccharomyces carlsbergensis* and *Candida krusei.*

TABLE 1

Effect of nutrients on the propagation of Candida krusei

	Hours						
	0	47	70	94	119	142	190
	pH						
Medium A[a]	5.2	7.1	7.2	7.2	7.2	7.5	7.6
Medium B	5.3	6.7	6.7	6.8	6.5	6.7	6.8
Medium C	5.3	7.1	7.3	7.6	7.8	7.9	7.9
Medium D	5.2	7.4	7.5	7.6	7.3	7.4	7.5
	Cell count per ml. × 10^6						
Medium A	6.0	187	210	175	165	200	200
Medium B	6.0	198	210	148	120	190	205
Medium C	6.0	355	432	390	375	395	400
Medium D	6.0	430	470	430	410	420	420
	% reducing sugar used as glucose						
Medium A	0	.....	49	.....	57	.....	59
Medium B	0	.....	72	.....	77	.....	77
Medium C	0	.....	63	.....	68	.....	70
Medium D	0	.....	70	.....	73	.....	74

[a] See text for formulas for media.

As indicated in Figure 4, with reference to *Pichia membranaefaciens* the amount of reducing sugar utilized as glucose after 48 hours did not vary significantly regardless of the type of medium employed. The same general pattern was followed by *T. utilis* and *C. krusei. S. carlsbergensis* utilized considerably less of the reducing sugar in Medium A, the olive rsidue hydrolysate, than they did in the other media.

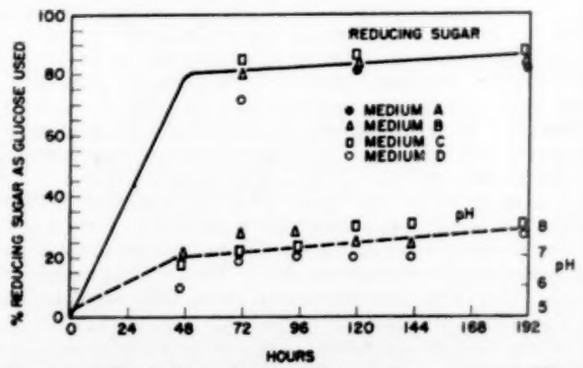

Figure 4. The effect of nutrients on sugar consumption and pH changes by Pichia membranaefaciens.

With reference to the pH changes as indicated in Figure 4, the same general trend was followed by all of the yeasts studied. Although the initial pH was approximately 5.2, the pH at the end of 48 hours had become approximately 7.0. During the remainder of the incubation period the pH increased gradually until it became about 8.0. This gradual increase is probably due to the utilization of organic acids by the yeasts *(2, 4, 5, 11)*.

From the data in Table 2 concerning the effect of nutrients upon the propagation of *Geotrichum*, it may be observed that urea is a better nitrogen source than ammonium sulfate. When 47.0 mg. of nitrogen as urea was added per 100 ml. of hydrolysate, we recovered

TABLE 2

Effect of nutrients on the propagation of Geotrichum species (Grown on shaker at 25° C. for a period of 120 hours)

Medium[b]	Final pH	Sugar used	Protein based on sugar used	Yield of dry yeast on sugar used
		%	%	%
A	7.6	76	11.8	35.1
C	8.2	75	10.7	37.0
D	8.1	80	20.2	39.15
E	5.7	86	13.95	51.5
F	6.6	87	18.55	43.75
G	7.7	87	17.75	39.0
H	5.85	96	22.2	61.0

[b] See text for composition of media.

36.0 mg. of nitrogen in the yeast cells, but when 106.0 mg. of nitrogen as $(NH_4)_2SO_4$ was introduced per 100 ml. of hydrolysate, only 27.0 mg. were recovered in the yeast cells. However, the cell weight of the latter was about 18% higher (proportionally greater carbohydrate concentration). The protein content of the cells when grown in 0.1% urea as nutrient was approximately the same as when grown on 0.5% malt extract and 0.5% yeast extract. If the concentrations of the latter were increased to 1.0% malt extract and 1.0% yeast extract, the protein content of the cells was increased by only 13.0%.

Even though maximum cell production for all the yeasts studied was in the media containing the nutrient adjuncts, considerable growth was obtained in the hydrolysate alone. The yeasts were also grown in a glucose-yeast extract medium for comparison. In many instances, more growth was obtained in the fortified hydrolysate medium than in the glucose medium if the results were based upon the consumption of carbohydrate calculated as glucose. For instance, the yeasts with more growth in the hydrolysate medium with the respective amounts of increased yield were: *S. carlsbergensis*, 18%; *P. membranaefaciens*, 14%; and *T. utilis*, 11%. *C. krusei* had an equal growth, and *Geotrichum sp.* had 7% less growth in the hydrolysate medium.

Under optimum conditions in our experiments, about 50.0% of the yeast dry weight was protein. On this basis 4.5 to 5.5% of the olive residue was converted to protein, calculated on the dry basis. Therefore, with 2 million tons of olive residue available, 90,000 tons or 180 million pounds of dry yeast protein may be produced per year.

The economical aspects of this problem have not been developed in detail since our principal interest was limited to the techniques of growing yeasts upon the olive residue hydrolysate. It seems probable that the yeasts could be produced quite economically by the use of crude sulfuric acid for the hydrolysis, lime water for neutralization, malt sprouts instead of malt extract, and dried fodder yeast cells rather than yeast extract.

In order to prepare the yeasts for human consumption, the cells could be separated from the liquor by centrifugation, washed first with slightly alkaline water and rewashed with a neutral potable water. This treatment should produce white to cream-colored cells which could be dried on a drum drier.

For animal consumption, the impurities of the medium would not need to be separated from the cells by washing, therefore, most of the liquid of the medium could be removed by a multiple evaporator system, the remainder removed by a drum drier. The effect of the cells upon the organoleptic qualities of animal flesh have not been determined, but we believe that yeasts grown upon the olive residue will be equal in quality to those produced upon sulfite waste liquor or similar substrates.

SUMMARY

The cellulose of the olive residue may be acid hydrolyzed to yield about 18% reducing sugar. Optimum conditions for hydrolysis were 2 successive acid treatments with 3.5% sulfuric acid using a liquid to solids ratio of 5 to 1 at a 120° C. for 3 hours.

Although the yeasts will produce some growth in the neutralized hydrolysate, accessory growth factors must be added for maximum growth. Yeast extract, malt extract, or a combination of the two were effective nutrient adjuncts.

The yeasts which we found to grow well upon the hydrolysate in the approximate order of effectiveness were *Torulopsis utilis, Pichia membranaefaciens, Geotrichum, Saccharomyces carlsbergensis,* and *Candida krusei.*

Yields of 50 to 65% of dry yeast, based upon the sugar used, were obtained with the various yeasts employed. Since about 50% of the yeast dry weight is protein, 4.5 to 5.5% of the olive residue is converted to protein. It is possible to produce 180 million pounds of dry yeast protein per year from 2 million tons of olive residue.

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Factors Affecting the Stability of Color of Canned Ripe Olives*

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The effects of such factors as the pH of the olives, the hardness of the water used in pickling, the addition of calcium and magnesium salts, and the types of containers used for storage, on the stability of the color of canned ripe olives are discussed.

The canned ripe olive trade and olive packers prefer canned ripe olives of black or very dark brown color. This color is not the natural color of the olive but is developed by oxidation of certain compounds of the olive at a slightly alkaline reaction. The color bases are thought to be the bitter principle, catechol tannins, and other orthodihydroxy phenolic compounds such as protocatechuic acid, catechol, etc.

A difficult problem is the one of retaining the black or very dark brown color after it has been developed by oxidation. It can be lost during lye (NaOH) treatment or subsequent leaching with water to remove the lye, or during sterilization of the canned olives and during storage after canning.

Before taking up these factors affecting color stability, a very brief outline of the pickling of ripe olives for canning will be given *(2)*.

In most plants the fresh olives are stored in redwood tanks in brine of 25-40° salometer reading for several weeks or longer before pickling, in order to firm the flesh, permit fermentation of the sugar to lactic acid, CO_2, etc., and to render the olives more uniform in their behavior during lye treatment and oxidation. They are next placed in shallow open vats and are covered with dilute NaOH solution, usually 1 to 1.5%, which is allowed to partially penetrate the skins. The lye is removed and the olives are then exposed to the air to oxidize for several hours or are aerated in water. Lye application and aeration are repeated several times, usually 5 to 8 times, over a period of several days. If the treatment is successful, a thin layer of the flesh immediately beneath the skin becomes black. Next a final but weaker lye solution (usually 0.5-0.75% NaOH) is applied and allowed to penetrate to the pits to destroy the bitter principle and to cure the flesh so that it will withstand sterilization at 240° F. (114.5° C.) after canning.

The NaOH is then replaced by water which is changed 3 or more times daily until the olives are free of NaOH. In most large plants the olives are leached until the pH value of the juice expressed from a sample of olives is well below pH 8, preferably about pH 7.2-7.5 *(3, 4, 9)*. They are then stored in dilute brine (10-12° salometer reading) for 1 to 3 days; canned in enamel-lined cans in fresh brine of 10-12° salometer; exhausted or otherwise vacuumized; sealed; and processed at 240° F. (114.5° C.) for 60 minutes.

If the first 2 or 3 NaOH solutions are allowed to penetrate too deeply, the dark color formed by subsequent oxidation is very apt to be lost during the final leaching of the olives to remove residual NaOH. Also, if the final lye solution used to destroy the bitter principle is too strong it will dissolve much of the color developed earlier in the process and will render much of the remainder soluble in water.

Effect of pH value on color development. Experiments in the Food Technology Laboratory of the University of California have indicated that the darkening of the color is most rapid at slight alkalinity, namely, at about pH 8.0-9.5. At high pH a brown color is formed which leaches out of the fruit during soaking in water; or if a black color develops it is soluble and is lost also. On these facts depends the usual multiple lye and multiple aeration process of pickling previously described. The NaOH solution penetrates only a very short distance in each application; hence only a shallow layer of flesh is made alkaline by the NaOH. Beneath this layer is untreated flesh which is acid in reaction. Therefore much of the NaOH is neutralized by acid diffusing into the NaOH zone, thereby reducing the pH to a favorable level for rapid blackening of the color.

It has been found in this laboratory that if after each lye treatment the olives are covered with dilute $NaHCO_3$ solution for 2-3 hours before aeration, the pH is buffered to a favorable level for oxidation and fixation of the color *(6, 7)*. Sancombe *(10)* observed that under practical conditions lye applications, if too severe, leach much color from the olives.

Effect of hardness of water used in pickling. Olive processors have long maintained that the hardness of the water used affects color retention. During the past 3 seasons olives of several varieties were pickled experimentally in this laboratory with waters ranging from soft to very hard. That is, the lyes and brines used in pickling were made up with these waters and the lye-treated olives were leached in them.

In one typical experiment 5 waters were compared. One of these was very high in dissolved solids, 1220 p.p.m., and in hardness, 490 p.p.m., expressed as $CaCO_3$. The softest water, Berkeley city water, contained 69 p.p.m. soluble solids and rated only 6.52 p.p.m. $CaCO_3$ in hardness. The other waters rated 476 p.p.m., 300 p.p.m., and 286 p.p.m. in hardness. Olives pickled in solutions made with the softest water (Berkeley City) were poorest in color; those pickled in the 2 hardest were darkest and of about equal color. However, those pickled in the water third in hardness were of nearly as poor color as those pickled in the softest water. In other experiments occasional irregularities of this type were encountered indicating that other factors than water hardness were not well controlled or that hardness is not the whole story. It was observed that during the final leaching of the olives in water to remove NaOH the amount of color dissolved from the fruit was much less in the hard waters.

The waters used in 12 different olive canneries located in 11 different cities or towns were analyzed and for comparison a very hard water from a well near Berkeley, California was included. Total solids content of the waters ranged from 60 p.p.m. to 1140 p.p.m.; pH value from 6.80 to 8.7; total hardness from 6.52 to 476 p.p.m. as $CaCO_3$; and calcium content from 21.2 to 97.4 p.p.m.

In general, the olive canneries that have hard waters have had less difficulty in retaining olive color during pickling and canning than do those that have soft waters although corrective measures are taken in some plants to counteract the effect of soft waters.

Effect of adding $CaCl_2$, $Ca(OH)_2$ and other salts. In experiments conducted in this laboratory during the past 5 years calcium chloride has been applied in dilute

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solution at various stages of the pickling process. Some of the data were reported by Krueger, Rivera, and Cruess in 1950 *(8)*.

In one typical experiment Manzanillo variety olives were darkened in color by several applications of dilute NaOH and exposure to air. They were then divided into 5 lots and stored for 24 hours in the liquids shown in the following tabulation. They were then treated with 0.75% NaOH solution to the pits; then leached with cold water changed 3 times daily until free of NaOH. They were then canned and sterilized. The final lye solution on lots 1, 2, 3, and 5 became very dark in color, indicating excessive loss of color from the olives; that on lot 4 remained light in color. Before canning, olives in lot 4 were darkest in color and firmest in texture.

After canning counts of brown, black, and soft olives per can were made with the following results:

Lot	Number of medium brown olives	Number of dark brown olives	Number of black olives	Number of soft olives
1. Check, water only	53	0	0	11
2. 0.01% $CaCl_2$	36	0	17	5
3. 0.10% $CaCl_2$	31	0	22	2
4. 0.30% $CaCl_2$	0	19	34	0
5. 0.50% Alumn	0	29	24	2

When applied as in this experiment the 0.01% and 0.1% $CaCl_2$ improved color retention somewhat but not nearly as effectively as did the 0.3%. The 0.5% alumn solution was less effective than the 0.3% $CaCl_2$, although superior in color retention to plain water.

In other experiments 0.4 and 0.5% $CaCl_2$ solutions used as in this experiment fixed the color satisfactorily; but made the fruit too hard in texture and complete leaching of the $CaCl_2$ from the olives required an excessively long time. Alumn in other experiments was not very effective in fixing the color and in several cases caused undue softening of the flesh.

In some experiments $CaCl_2$, 0.1 to 0.3%, was added to the NaOH solutions used in pickling. It retarded lye penetration markedly but greatly improved color retention.

$MgSO_4$ used as outlined in the foregoing experiments also aided greatly in color retention, but was less effective than $CaCl_2$. It was difficult to leach from the olive tissues and when not thoroughly removed gave a bitter, brackish flavor to the canned fruit.

In several experiments fresh olives were stored for several months in NaCl brines to which had been added 0.5 to 1.0% of $CaCl_2$. They were then pickled in the usual manner in comparison with olives of the same lot stored in plain brine containing no $CaCl_2$. Again the $CaCl_2$ treated olives retained their color much better than did the untreated, and were firmer than the untreated. Evidently the Ca^{++} reacts with pectic substances in the fruit to form compounds that impart firmness. Where $CaCl_2$ is used penetration of the NaOH into the olive flesh is markedly retarded; a fact that must be taken into account in practice.

In Egypt olives are pickled in $Ca(OH)_2$ solution, or rather in milk of lime. The pickled olives are very firm and free of bitterness; but are straw yellow or brown in color, as no attempt is made to blacken the olives by oxidation.

In several experiments reported by Cruess and Rivera *(7)* mixtures of NaOH and $Ca(OH)_2$ were used in pickling olives, and in others $Ca(OH)_2$ was used only for the final lye treatment. In all cases color retention was much improved by use of the $Ca(OH)_2$; but it usually made the olives too firm in texture and was very difficult to leach from the fruit completely; hence a brackish taste developed in several lots during sterilization. $CaCl_2$ appears to be preferable to $Ca(OH)_2$.

Since sea water is rich in magnesium salts, olives after preliminary lye treatments and air exposures to develop color were soaked by Cruess, Krueger, and Rivera *(8)*, for 48 hours in mixtures of 5, 10, 20, and 25% of sea water and tap water. Pickling was then completed in the usual manner and the olives were canned. In all cases color retention was greatly improved by the dilute sea water treatment; even when as little as 5 ml. of sea water to 95 of tap water was used. However, 10 volumes of sea water to 90 of water appeared to be the preferred ratio.

In the production of salt from sea water there remains a bittern of about 30° Bé that is very rich in magnesium salts. Olives after the usual preliminary lye treatments and air exposures were soaked for 48 hours in water containing from 1 to 10 ml. of bittern to 99 to 90 ml. of water. The pickling was then completed and the olives canned. As little as 1 ml. of bittern to 99 of water greatly aided in color retention although a ratio of 3 ml. to 97 ml. of water was somewhat better.

It is customary in some olive pickling plants to store olives in NaCl brine of 20-30° salometer for several days after color has been developd but before the final lye application. In several experiments this treatment improved color retention but was much less effective than $CaCl_2$ or dilute salt bittern *(8)*.

Salt added to the NaOH solutions used in pickling to increase the density to 20-25° salometer materially improved color retention in these experiments; but, also was less satisfactory than $CaCl_2$ or dilute bittern.

Effect of pH value of olives at time of canning. It has been recognized by commercial olive canners that olives must be thoroughly leached with water to remove all or nearly all of the NaOH from the tissues before canning in order that the color will not bleach seriously during sterilization and storage and that a soapy flavor does not develop.

In order to obtain quantitative data on the effect on color of the pH value of the olives at the time of canning, pickled olives ready for canning were obtained by Cruess *(4)* from 7 commercial plants. The pH value of juice expressed from the olives from the different canneries ranged from pH 7.1 to 8.3. They were then soaked for several days in 12 lots of 10° salometer brine brought to the various pH values shown in the following table. They were then canned in plain 12° salometer brine in the usual manner. The pH values of the olives were taken before and after canning and color of the olives observed 1 month after canning. Average values are given in the table as there were 6 lots of olives at each pH value. Evidently olives of pH 8.0-8.1 at time of canning were too high in pH or alkalinity to retain their color well after canning. Those acidified with citric acid to pH 6.6 lost much of their color during canning and 1 month of storage. But those acidified to pH 4.1

TABLE 1
Effect of pH value at time of canning on color retention

Experiment number	Solution in which olives were soaked before canning	Average pH value of olives before canning	Average pH value one month after canning	Average color one month after canning
1	Plain 12° salometer brine	6.6	6.6	Black
2	Dilute HCl of pH 2.2	2.6	6.2	Dark brown
3	Dilute HCl of pH 4.5	4.1	6.6	Black
4	0.05% citric acid	6.6	6.1	Brown
5	0.10% citric acid	4.3	5.9	Very light brown
6	0.20% citric acid	4.0	5.7	Very light brown
7	0.30% citric acid	3.9	5.1	Very light brown
8	0.25% $NaHCO_3$	7.4	6.7	Black
9	0.05% NaOH	8.0	6.8	Dark brown
10	0.10% NaOH	8.1	6.9	Medium brown
11	0.20% NaOH	8.7	7.0	Very light brown
12	0.30% NaOH	8.8	8.0	Yellow

with HCl retained their color well, probably because HCl has practically no buffering power; hence the buffer substances in the olives raised the pH during sterilization to a level that retained the color. Olives acidified to pH 4.3 with citric acid before canning bleached badly in color in the cans. Citric acid is a good buffer, hence the pH value did not rise to as high a level as in olives acidified to an even lower pH value with HCl before canning.

Olives in experiments 10, 11, and 12 were soft in texture and soapy in taste after canning, as well as bleached in color. Gibson and Develter *(9)* have obtained further data on this point under plant conditions and found that the effect of pH value on color retention is affected to some extent by other conditions.

Effect of other factors. While the observations are rather old on effect of container, they will be mentioned for sake of completeness. In 1917 several lots of ripe olives were canned in plain tin cans, enamel-lined cans, double enameled cans and in glass jars *(5)*[b]. Immediately after canning the color of the olives in the 4 lots was about equal; but after 6 months of storage those in plain tin had bleached in color seriously. Those in the other 3 types of containers had held their color almost perfectly; at 1 year those in the single enamel cans were slightly lighter in color than in the double enamel cans and glass jars.

At present all cans used for ripe olives are lined with special enamel and color retention is excellent. In glass jars the brine remains dark in color; in enameled cans it is light in color, probably because of the reducing action of very small amounts of nascent hydrogen.

The bitter principle of the olive is oleuropein, a glucoside that when treated with NaOH gives orthodihydroxy compounds including caffeic acid. Olives soaked in brine containing 0.5 to 1.0% of the purified bitter principle became intensely black during pickling and retained the color well in canning (Cruess, unpublished data, 1931). Varieties such as the Mission and Manzanillo, which are rich in oleuropein, blacken more readily and the color is retained better than in varieties of low oleuropein content such as the Sevillano and others. Consequently it appears safe to state that oleuropein is concerned in color formation and retention.

If olives are impregnated with dilute pyrogallol or dilute catechol before or during pickling, as shown in experiments in this laboratory (unpublished data) a stable black color develops during oxidation and is well retained in canning. Or if they are impregnated with a very dilute solution of an iron salt the results are similar except that the fish acquires a bluish cast, as is well known to olive processors. These and other "chemical methods" of artificial coloring of olives are prohibited by the California State Board of Health.

Wylie *(11)* has confirmed the general belief of olive processors that on prolonged storage of ripe olives after canning in enamel-lined cans considerable color is lost. Such loss is apt to be more extensive at warm storage temperatures. However, usually color loss is slight at normal temperatures in a 12 months' storage period. It is very severe in plain tin cans, however, as previously mentioned.

Ball *(1)* has found that pasteurization of pickled ripe olives at about 175° F. (79° C.) before sorting for canning intensifies differences in color, making it possible to secure greater uniformity in color of the canned olives.

SUMMARY

1. The black to dark brown color of canned ripe olives is formed by oxidation of the natural color bases of the olive at slight alkalinity.

2. Color formation is most rapid at a pH range of about 8.0-9.5 and its retention is better in this range.

3. In order that color may be retained well the lye penetration during color formation should be shallow.

4. Color retention is better in olives pickled in solutions made up with hard water, probably because of color fixation by calcium salts.

5. When $CaCl_2$ was used in low concentration, 0.1-0.5%, in the storage brines before pickling, or in the lye solutions or between lye treatments color retention was greatly improved. $MgSO_4$ was also effective but less so than $CaCl_2$.

6. Dilute sea water and dilute salt bittern also fixed the color very effectively, probably because of their content of magnesium salts.

7. $Ca(OH)_2$ used during lye treatment also improved color retention but often made the olive flesh too hard and was difficult to leach out from the tissues.

8. Brine applied during lye treatments or between them had a moderately favorable effect on color retention but was much less effective than $CaCl_2$.

9. The pH value of the olives at time of canning greatly affected color retention during canning and subsequent storage; a pH range of 7.0-7.5 appears to be most favorable. A pH 8.0 or above at the time of canning caused loss of color in experiments in this laboratory.

10. Enamel-lined tin cans are necessary for color retention in canned ripe olives. Glass is also very satisfactory in that regard.

11. Oleuropein, the bitter principle of olives, is one of the color bases involved in the blackening of ripe olives during pickling.

[b] Also Cruess, unpublished data.

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Canning "Little Tuna" (Euthynnus Alleteratus)[a]

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A study of all stages in canning little tuna has been made. The effect of precooking times and temperatures, acid dips and acid blanches, chemical bleaches, packing mediums, storage times and temperatures, type of fill, and processing and cooling on the flavor, texture, and color of canned little tuna has been investigated and reported. Recommendations for canning, based on the findings herein reported, are given.

For canning, fish, like fruits and vegetables, must be of varieties suitable for the purpose. The horticulturist can develop varieties specially adapted to canning, but the fishing industry is limited to the utilization of existing species. New items are added to the list of canned fishery products from time to time, to some extent by developing new formulas which require the diversion of raw material from the fresh, frozen, or cured markets. The development of new areas through exploratory fishing may result in the discovery of varieties suitable for canning. The principal source of new items is the utilization of varieties known to the fisherman but not utilized extensively for human consumption in the fresh fish market because of prejudice or related reasons. A good example of this is the Pacific tuna industry.

For many years the tuna on the coast of California were valued only as good sport fishing varieties. The sport fishermen did not eat them for they were regarded as of low quality, principally because of lack of knowledge of good cooking methods. That condition still holds true today. Though there is some increase in the sale of tuna on the fresh market, it is one of the underutilized varieties. California sardine canners experimented with canning tuna in the first years of this century, when foreign competition had a depressing effect on the domestic market, in an effort to increase their production. The first successful California tuna pack (of 2000 cases only) was not packed until 1909, and tuna was not packed on a large scale until after World War I *(3)*. Demand and production have increased greatly since that time. In 1950 the Pacific coast states produced more than 8 million cases of tuna. In addition more than half a million cases of tuna and tuna-like fish were imported. Tuna threatens to displace salmon as the most important canned fishery product in the United States.

Since the beginning of World War II, the demand for canned fishery products has been greater than the supply, and world conditions over the foreseeable future promise a continuance of this trend. At the same time most of the areas of production are at points far removed from the principal consumption centers and in turn the newer fishing grounds are at long distances from the canneries. The consequent increase in costs has renewed interest in fish canning, especially of tuna or tuna-like fish, along the Atlantic coast, near the principal markets of the United States.

The "little tuna" *(Euthynnus alleteratus)* is more generally known under a variety of common names as: bonito, spotted bonito, albacore, false albacore, watermelon bonito, blood bucket, and boohoo. While it has been taken in commercial catches of the Atlantic coast, especially the pound-net fisheries, there has been very little demand for this species in the fresh fish market, because of the dark color and strong flavor of the meat.

A canner on the Eastern Shore of Maryland, identifying this fish with the albacore of the Pacific coast, put up a small pack in 1946 which was sold on the New York market. The Food and Drug Administration, taking exception to this labeling, identified the fish as to species and informed the packer that it could be called "light meat tuna." The pack sold well, and as a result, other canners on both Atlantic and Pacific coasts showed interest in the possibility of this fish as a new source of raw material. A study was made of the probable abundance of this species *(1)*, and a report by the Market Development Section of the Fish and Wildlife Service indicated that the little tuna was to be found from New England to and into the Gulf of Mexico in sufficient quantity for commercial canning.

The Food and Drug Administration was questioned as to the propriety of labeling the canned product of the little tuna as "light meat tuna" and replied as follows:

[a] Presented at the Eleventh Annual Meeting of the IFT, New York, N. Y., June 19, 1951.

"The little tuna is closely related to the skipjack, *Katsuwonus pelamis*, and is one of the species which are properly classed as tuna. The canned product prepared by the usual procedure in canning tuna is quite dark in color, somewhat coarse in texture, and relatively strong flavored when compared with packs of yellowfin or bluefin tuna. For these reasons we are reserving final judgment as to the aptness of the 'light meat' designation. This species has received only limited attention commercially and we have no knowledge of consumer reaction to the canned product prepared from it. At the present time we are not taking exception to the designation of 'light meat tuna' when applied to the usual oil pack prepared from *Euthynnus alleteratus*."

The Fish and Wildlife Service therefore decided that research on methods of canning the little tuna was necessary. A comprehensive study was outlined with the objective of working out a satisfactory packing procedure, improving the color of the flesh, the texture, and flavor if possible. It also included determination of the effect of storage and handling on raw material, loss of raw material, yield and other packing information needed by the commercial canner, including packing costs. Some work was also outlined on the preparation of specialty canned products from this species.

CANNING PROCEDURES

To determine the effect of freezing on raw material, a pack of fresh tuna was canned as a control and compared with lots frozen and held at 0° F. (—18° C.) for 90, 120, 150, and 180 days. The fish were glazed at frequent intervals during storage to prevent deterioration such as desiccation or rancidity. In the examination of the canned product no difference could be detected between the fresh tuna and 90 day old fish. Fish held 120 days were slightly stronger in odor and flavor. Tuna frozen for 150 and 180 days had a much stronger odor and flavor, also the recovery rate was somewhat lower. This was due to an extra amount of discoloration in the light meat areas, especially the surface and edges. It was concluded that little tuna could be safely held in storage for 3 months before canning, without affecting the quality of the product in any way, but that deterioration set in soon after this limit was reached, at first slowly, then rapidly, so that fish held 6 months were not fit for canning purposes.

Several series of packs were made in an effort to obtain information on factors affecting color. Since the earliest days of tuna canning, both here and abroad, it has been claimed that fish given a thorough bleeding resulted in a much lighter canned product. At first this was standard operating procedure in the California tuna industry *(2)*, but the practice was later abandoned when the production rate became large and the fishing grounds far distant from the canneries. To determine the effect of bleeding on color, the throats of live tuna were cut as soon as they were taken out of the water and the gills were pulled out. The fish were hung so that they had every opportunity to bleed thoroughly before landing. Other fish taken at the same time were brought in, in the round and were left uncut and not bled. Packs were made from the two lots of fish at the same time using standard tuna canning procedure. No difference in color or other quality factors could be determined when the packs were examined. A panel of examiners agreed that both were of the same color, a shade listed as "salmon" in the Maerz-Paul color charts *(4)*. The packs were also compared with Pacific coast canned tuna.

In the next series of packs on color, a lot of fish was divided in 3 parts. The first portion was filleted, the dark meat areas were cut away and the fillets were precooked for 45 minutes at 216° F. (102° C.). The rest of the canning procedure was standard *(3)*. The second lot of fish was filleted and dipped in a 90° salometer brine for one minute, then given the same precook. The third lot was a control. These tuna were not filleted or brined, but packed by the standard method. All three lots were examined at the same time in comparison with each other and a sample of Pacific tuna. All 3 lots were within the same color range and all were darker than the sample of California tuna. The canned packs made from fillets were judged tougher in texture and more fibrous than fish canned by the standard method.

Various bleaching methods were tried experimentally to obtain a lighter color in the next series of packs. Raw fillets were soaked for 30 minutes in a 90° salometer brine, then precooked and processed. Raw fillets were soaked for 30 minutes in a 90° brine containing 2% acetic acid. Precooked fish, cut in can length pieces were dipped for 1 minute in a brine containing 2% hydrochloric acid. Other can-length pieces were cooked overnight in a 2% hydrochloric acid solution. Raw fillets were precooked in a 50° salometer brine. Other raw fillets were precooked in a 50° brine containing 2% acetic acid, while still a third lot of fillets were precooked in a 50° salometer brine containing 1% citric acid.

Soaking in brine, or in brine with acetic acid, did not result in a canned product with a lighter color. Dipping the cooked fillets in a weak hydrochloric acid solution had no effect. Can-length pieces soaked overnight in a weak hydrochloric acid solution, were bleached white on the surface, when examined after canning, but on breaking the contents open, the interior had the same salmon shade as unbleached tuna. Precooking in brine, or in brine with acetic or citric acids results in a product with a dull grayish shade on the surface, and the same salmon shade inside. Samples precooked in brine were denser and tougher in texture than the standard pack. Also, the loss in packing, especially in precooking, was greater.

To determine the effect of gutting and freezing, and of freezing at temperatures higher than 0° F. (—18° C.) little tuna were frozen round and stored at 0° F. A second lot was gutted and washed thoroughly and then stored at 0° F. A third lot was frozen round and stored at 10° F. (—12° C.), while a fourth lot was gutted and washed and stored at 10° F. The fish were in storage for approximately 6 months.

When they were canned and later examined, it was found that the fish frozen round and held at 0° F., were in the best condition. The gutted fish held at 0° F. showed some darkening of the flesh in the area of the belly cavity, while the pack from these fish had a strong flavor and there was some odor of rancid fat. Packs from the fish frozen round and stored at 10° F., had a rancid odor and flavor, while the gutted fish held at this temperature showed a great deal of discoloration, both in the body cavity and the cut fillets. Loss in packing was greater and the cut portions had a rancid odor and flavor. The gutted fish also showed much desiccation while the fish frozen round did not. Little tuna should not be gutted before freezing, should be stored at temperatures of 0° F. or lower and should be kept well glazed.

A study was made of thawing methods, but the entire series as originally outlined was not completed, so additional work should be done before any positive conclusions are drawn. Tuna were air thawed for 36 hours at 35° F. (1.5° C.) and for 14 hours at 70° F. (21° C.). Standard methods of packing were used. One lot of tuna was precooked when frozen, as a control.

The characteristic crystalline-shaped perforations appeared after precooking in both the frozen tuna, and the fish held at 35° F. The precooked flesh was also soggy in both instances, in spite of a longer come-up period in precooking. Tuna air thawed for 14 hours at 70° F. were satisfactory in quality after precooking, but were

considered rather soft and difficult to handle in butchering. Little tuna were also thawed in running water for 2, 3, and 4-hour periods. Fish thawed less than 4 hours showed some ice perforations after precooking, and were not thawed sufficiently for thorough butchering and cleaning. This was also found to occur when the fish occupied 50% or more of the volume of the tank, and the flow of water reduced to less than 1 inch diameter.

Series of packs were prepared to determine the effect of time and temperature on precook. Fish were precooked from 45 to 240 minutes at 212° F. (100° C.), from 45 to 160 minutes at 216° F. (102° C.), from 45 to 125 minutes at 221° F. (105° C.), and from 30 to 90 minutes at 240° F. (114° C.). Packing procedures were standard, except for the precook.

All packs precooked at 212° F. showed excessive crumbling with a high proportion of flakes. Excessive moisture was present, even in the pack precooked for 240 minutes. Packs precooked at 216° F. showed crumbling and excessive moisture at the lower time range, but fish weighing from 8 to 10 pounds given a precook of 90 minutes, or those weighing from 12 to 15 pounds given a precook of 2 hours, showed a good texture and moisture content in the canned product. The packs precooked at 221° F. showed little, if any, difference from the series at 216° F. Of the packs precooked at 240° F., those given precooks of less than 80 minutes were crumbly and showed excess moisture. Those precooked 80 minutes or longer were tough or "chewy" when tasted after canning. Also the percentage of loss in precooking was greater, and the yield of finished product was less. It was concluded that precooks of from 216° F. to 221° F., gave the best results, and that the optimum time for little tuna weighing 10 pounds or less was 90 minutes, and for tuna from 12 to 15 pounds was two hours. Fish weighing more than 15 pounds should be given a precook of 2½ hours *(3)*. It was also found that all precooks at all temperatures in excess of the optimum times resulted in a coarse texture in the canned product, except when the fish were precooked at 240° F., when coarseness of texture appeared sooner, in the 70 to 80 minute range.

Records were kept of the color after precooking, in all the precook packs. Color after precook was compared with color after canning. So far as could be determined there is no relation between temperature and time of precook and color after canning. The color after precook was in the same range for all precook packs and compared very favorably with the color of canned Pacific light meat tuna. Darkness in color occurred only after process.

The proportion of flakes in all packs was 20%, except in the series of precook packs, where it was considerably more. In packing the smaller fish, the proportion of flakes was somewhat greater than for large fish. Small fish do not make a good solid pack, and are much better ground mechanically into flakes, with a higher total yield.

Three types of experimental packs were made to cover the stage of can filling. In the first series, three levels of fill-in weight were used, namely, 5.75, 6, and 6.25 ounces. In examination of the packs, many of the 6 ounce fill and most of the 6.25 ounce fills were found to have a light brown or scorched surface, with a deeper color inside than normal. All of the "scorched" cans, and some of those in the 6 and 6.25 ounce fill-in levels which did not show this discoloration had a strong flavor which might be characterized as "caramelized." It is believed that average fill-in weights of more than 5.75 ounces to the 307 x 113 can, result in poorer color and flavor.

Packing media or added ingredients such as oils were dealt with in the second series of experimental packs covering the stage of can filling. Packs were prepared with various oils, cottonseed, olive, soybean, peanut and corn, and also 3% salt brine. All of the oils were found to be about equally desirable in examination of the packs, except soybean, which was rated somewhat lower because of a slight "earthy" flavor. The pack in 3% brine compared very favorably with the oil packs, both in appearance, flavor and texture. It is believed that "brine" or "natural style" packs of tuna should find a wide use commercially when oils are scarce or high priced, though the American tuna canning industry has been limited to the oil pack to date. The brine apparently serves as well as oil as a protective medium.

The third series of type of fill packs consisted of tuna mechanically grated, tuna cut into cubes and compressed into a cylinder ("bite size" or "chunk style") and tuna mechanically grated with the addition of 20, 40, and 50% dark meat. A standard type "solid pack" was prepared as a control for this series. The fill-in weight for this series was 5.25 ounces. The standard process of 75 minutes at 240° F. was used. The chunk-style pack, when examined had a dark color and an overcooked flavor. The color of the grated light meat pack was lighter than that of the standard solid pack used as a control, and was in the same color range as a sample of California bluefin tuna with which it was cut for purposes of comparison.

The appearance of the grated, mixed light and dark meat packs was not good, and they were unacceptable in flavor to a panel of examiners, even when the lower levels of dark meat were added. The flavor was judged much too strong and there was a "kick back" effect. It is interesting to note however, that two Turkish visitors who were present at the cutting preferred the mixed light and dark meat packs. It is possible that there may be some market for such a pack in the Mediterranean area and the Near East.

Under processing it was planned to make heat penetration tests and inoculated packs. The inoculated packs were made, but work on the little tuna was concluded before it was possible to do the work on heat penetration. The object of making the inoculated packs was to determine the heat process necessary for sterilization. Artificial inoculation was done with spores of a significant spoilage organism. The test organism was P.A. No. 3679, a heat resistant spoilage organism obtained from the laboratories of the National Canners Association.

A standard type solid pack was used, with a fill-in weight of 5.75 ounces of tuna, to which was added ½ ounce of salt and 1.5 ounces of cottonseed oil. Before addition of the oil, a hole was made in the geometrical center of the contents of each can to be inoculated, and 0.1 ml. of the inoculum, containing 10,000 organisms was inserted by means of a sterile pipette. The hole

was closed and marked with a piece of toothpick. The oil and salt were then added, the cans were exhausted for 10 minutes, sealed and processed. All cans in this series of packs, including controls, were incubated at 37° C. There were 24 inoculated cans and 24 uninoculated cans (controls) in each pack. Heat processes were at two levels, 230° and 240° F. Spoilage results are shown in Table 1.

TABLE 1
Spoilage results of inoculated packs of little tuna

Code No.	Number cans		Processes, minutes		Cans spoiled	Spoilage
	Control[b]	Inoculated	230° F.	240° F.		
						%
14A	24	24	85	....	24	100
14B	24	24	100	....	8	33.3
14C	24	24	120	....	1	4.17
14D	24	24	130	....	0	0
14E	24	24	140	....	0	0
14F	24	24	150	....	0	0
14G	24	24	160	....	0	0
14H	24	24	....	45	24	100
14I	24	24	....	55	6	25.0
14J	24	24	....	65	2	8.3
14K	24	24	....	75	0	0
14L	24	24	....	85	0	0

[b] No spoilage in any control.

No spoilage occurred in any control cans. The results of the inoculated pack show an experimentally derived process of 130 minutes at 5 lb. pressure (228° F.) or 75 minutes at 10 lb. pressure (240° F.). In the organoleptic examination of the various packs it was noted that the packs processed at 228° F. were lighter in color than those processed at 240° F. The packs processed at 240° F. were of the same color regardless of time processed. The packs processed at 228° F. for 130 minutes or less were lighter in color than those processed at 240° F. Little tuna packs processed at 228° F. were comparable to packs of skipjack in color as "light meat" tuna. It is believed that a process of 120 minutes at 228° F. would represent a satisfactory minimum process for 307 x 113 cans, when consideration is given to the difference in heat resistance between the inoculating organism (P.A. 3679) and *Cl. botulinum*. Additional tests should be made to verify this belief.

SUGGESTED METHOD OF CANNING LITTLE TUNA

After a study of the various series of packs the following method is outlined as a suggested procedure for canning little tuna. Unless the tuna are to be used immediately after landing they should be frozen in the round at 0° F. or lower. They should be well glazed before going into storage at 0° F. Higher storage temperatures will adversely affect quality and length of storage. Thawing should be done in running water, piping at least one inch diameter, and the fish should not fill more than 50% of the thawing tank or the thawing will be incomplete.

After thawing the fish should be eviscerated and washed thoroughly. At least 20 minutes "come up" time (the period from the moment when steam is turned on until cooking temperature is reached) should be allowed in precooking. For little tuna of less than 12 pounds the precook should be 1.5 to 2.0 hours at 216° F. Fish weighing 12 pounds or more should be precooked for 2.0 to 2.5 hours. Allow the fish to cool overnight or for a period of 14 hours, if the temperature averages 70° F. If the temperature is 80° F. or higher, cooling in chill storage at 35° F. is suggested. After removing dark meat and other waste the fillets of light colored meat thus obtained should be inspected and trimmed. The meat should then be cut and filled into the cans as rapidly as possible. Oxidation and darkening of color occurs rapidly when the precooked meat is allowed to stand in the open.

It is suggested that cut pieces be dipped for one minute in a vinegar solution with an acetic acid content of 1.5%. It is an added safety factor for a pack given a minimum process, becausse of the susceptibility of these tuna to darken through overprocessing. It does not seem that this blanch is itself of much value in obtaining a lighter color.

"Solid pack" tuna should have a fill-in weight of 5.75 ounces and "flakes," "grated," or "chunk style" packs 5.25 ounces. The can contents must be compressed mechanically into a solid cylinder in grated or chunk packs, or the oil will be absorbed leaving a dry can which will not only have darker colored meat, but it will be stronger in flavor. The grated pack is believed to give a better quality product, which may be packed more successfully as a commercial article than the solid pack.

The quantity of salt added should be ½ ounce, and the oil 1.5 ounces for ½ tuna (307 x 113) can. The exhaust should be not less than 5 minutes at 212° F., so that an initial temperature of 160° F. is obtained at the start of the process. The suggested process is 120 minutes at 5 lb. pressure (228° F.) for the 307 x 113 size can, with a come up period of at least 7 minutes before the retort reaches processing temperature. Additional work on process time is recommended. The pack should be water-cooled promptly after processing, with a sufficient volume of water so that cooling proceeds rapidly.

Changes may be indicated in the suggested method as additional data are obtained.

SUMMARY

Small commercial packs of "little tuna" which have been made during the last few years show that a canned product of satisfactory quality may be prepared but that the California methods of canning cannot be used unchanged. Therefore, a study of all stages in canning little tuna has been made.

It was found that excessive precook resulted in toughness of texture. When given the standard California process, the color was darker than desirable for light meat tuna. A lighter color was obtained when the packs were processed at a lower temperature. A short process at higher temperature did not result in a lighter color. Acid dips and acid blanches were not effective and chemical bleaches had only a surface effect on the color. All vegetable oils were found to be satisfactory packing mediums except soy bean oil, which while usable was not as desirable as the others.

Data have been collected on yield, effect of freezing, and storage at various temperatures on raw material, thawing, precooking, type of fill, processing and cooling. A method for canning little tuna, based on these data, has been given.

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Notes and Letters

The Use of Lycopene Determinations for Detecting Added Water in Canned Tomatoes

Ordinarily, the immersion refractometer is used for the detection of added water in canned tomatoes. However, the usefulness of this method is limited on account of the considerable variations which occur in the natural water content of tomatoes as the result of differences among varieties, soils, and especially climatic conditions. Thus, the soluble solids as measured by the refractometer may vary from more than 9% to less than 5%. Since these solids are water soluble, there is an exchange of these soluble substances between the tomatoes and the liquor surrounding them, so that after a given period of time an equilibrium is established where the soluble solids content of the liquor is essentially the same as that of the tomatoes. Hence, this method is effective only when reference can be made to the original refractive index of the raw material.

An ideal substance for detecting added water therefore, should be some material that is specific to tomatoes, and that is not water-soluble. Such a material is lycopene, the pigment responsible for the red tomato color. In connection with work on tomato color *(1)* a simple and rapid method was developed for lycopene determination.

In this method a 5-g. sample of pulped tomatoes, or tomato juice, or liquid, is blended in a Waring blendor with about 70 ml. benzol for 5 minutes. The blendor's contents are then transferred to a 100-ml. graduate cylinder and made up to volume with additional benzol. A 2-ml. aliquot is transferred to a 15 ml. centrifuge tube, made up to 10 ml. with benzol, centrifuged, and transferred to a suitable cuvette for a determination of transmittance in a photoelectric colorimeter or spectrophotometer at a wave length centered at 485 mμ.

When a can of tomatoes is drained, the liquid, if it consists of tomato material, should have a lycopene content very similar to that of the tomatoes retained on the screen. However, if water is added, the lycopene in the liquid portion will be diluted in direct proportion to the amount of water added, since the lycopene in the tomatoes is not water soluble, and cannot leach out as do the water-soluble solids.

The lycopene content in tomatoes varies considerably, increasing from none in green tomatoes, to a maximum content in fully ripe tomatoes that were grown under moderate (60-80° F.) temperature conditions. It is therefore not possible to establish any given lycopene level in the drained liquor as a standard below which the addition of water may be assumed. It is necessary to use the tomatoes in the particular can as a reference, and to determine whether the lycopene content of the liquor is appreciably lower than that of the tomatoes in the same can.

If the juice in canned tomatoes would always be composed of the same material as the solid portion except that it had been comminuted before or after canning, the above method would be infallible for the purpose of detecting added water. However, trimmings and the poorly colored tomatoes are at times used as a source of the added juice. This juice would have a lower lycopene content than the better colored tomatoes to which it was added. In order to allow for such situations, it would be necessary to allow the drained liquor in canned tomatoes to have a somewhat lower lycopene value than found in the tomatoes themselves.

The data in Table 1 show the relationship of lycopene content in the liquor to that in the tomatoes, when tomatoes of different quality are used in conjunction with differing amounts of water, as the added liquid in canned tomatoes.

TABLE 1

Relation of the lycopene content in canned tomatoes to the lycopene content of the drained liquor

	Ratio of lycopene in the tomatoes to lycopene in the liquid [b]					
	Juiced tomatoes used as added liquid			Trimmings and poorly colored tomatoes used as added liquid		
	Juice only	Juice and Water, 1:1	Water only	Juice only	Juice and Water, 1:1	Water only
U. S. No. 1 Red Tomatoes						
Slack fill	1.0	2.1	6.5	2.4	3.3	7.8
Normal fill	1.0	1.9	5.8	2.2	2.6	5.8
U. S. No. 2 Red Tomatoes						
Slack fill	1.0	2.0	8.3	2.1	3.2	10.9
Normal fill	1.0	1.7	6.7	1.7	3.0	8.1

[b] Relative lycopene values obtained by interpolating from transmittance data plotted on semi-log paper.

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Book Review

INDUSTRIAL OIL AND FAT PRODUCTS. Second completely revised and augmented edition. By Alton E. Bailey. 967 pages. Interscience Publishers, Inc., New York, N. Y., 1951. Price $15.00.

The first edition of this work which appeared six years ago has become such an indispensable tool wherever fats and oils are produced, processed, or consumed that a current revision is most timely. The second edition, besides being up to date, is even more complete than the first.

The author has rewritten practically the entire text and added much new material. In every respect, it appears to contain the latest information available on all aspects of fats and oils, with particular emphasis on plant operation and the scientific fundamentals important thereto. Only minor changes have been made in the outline of subjects covered, and the contents include detailed discussions of: A. The nature of fats and oils; B. Raw materials for oil and fat products; C. Industrial utilization of fats and oils; D. Unit processes in oil and fat technology.

The chapters on unit processes include handling, storage, and grading of both oils and oil-bearing materials, as well as sections on various plant operations of the industry, such as extraction, refining, bleaching, hydrogenation, splitting, soap-making, fractionation, homogenization, etc.

This volume is a very necessary tool in every office and laboratory concerned in any way with fats and oils, and it will prove of particular value to chemists and engineers engaged in the production or processing of fats. It is well documented and very readable throughout and deserves a regular place on the book shelf along with the handbooks and other standard works on which oil technologists rely. The author is to be commended for the scope and excellence of this latest contribution.

WARREN H. GOSS.

THE MOLDS AND MAN. By Clyde M. Christensen. 244 pages. University of Minnesota Press, Minneapolis, Minn., 1951. Price $4.00.

In this book Dr. Christensen has covered the activities of fungi and their relation to men in a refreshing and intriguing manner. While in his prefatory note he indicates that the book is designed not only for beginning students in mycology, whether amateur or professional, but also all those who, either for practical reasons or for pure enjoyment, might want to become acquainted with these prevalent and interesting and often important plants. In the reviewer's opinion, the book certainly fulfills the purpose for which it was written. It is recommended for reading by anyone who knows little about fungi but who would like to learn without much effort about the exciting things they do and the manner in which they live.

The book starts out with a discussion of where and how fungi grow, how they reproduce, and how they disseminate. It then deals with the intriguing relationships with other plants and animals, the undesirable things that fungi do, such as parasiting plants and animals, and the destruction of commercial products. Following this, a chapter deals with the industrial exploitation of fungi and indicates some of the desirable things they do. The last chapter is concerned with classification.

The author has presented enough information to familiarize the reader with the subject without imposing much of the drab material so characteristic of this area. The printing is good and easy to read, and the binding is satisfactory. Pertinent references are included. In the reviewer's opinion, the book is rather meagerly illustrated for the audience for which it was written. More illustrations such as those on pages 10, 83, and 154 would add much to this book.

E. M. MRAK.

TROPICAL NUTRITION AND DIETETICS. Third editio... By Lucius Nichols. 476 pages, 74 illustrations. Williams and Wilkins Company, Baltimore, Md., 1951. Price $8.00.

In this volume accurate information on basic nutrition and applied nutrition have been nicely integrated by a medical doctor who has had long personal contact with the tropics and its food and nutrition problems. This book is concise and readable and should be useful to physicians, nutritionists, dietitians, social workers and biochemists who are working in tropical and semi-tropical countries. It is to be recommended as a text-book for students in one of the above disciplines who contemplate working in the tropics.

The book consists of a discussion of the science of nutrition and a description of deficiency diseases (Chapters I-IX); a brief discussion of food processing and preparation (Chapter X); descriptions of the various tropical foods of plant and animal origin (Chapters XI-XIV); the energy values of foods and calories in diets (Chapter XV); diets for institutions, for workers, and for infants and children (Chapter XVI); public health nutrition activities (Chapters XVII-XVIII), food poisoning (Chapter XIX); food analysis and diet computations (Chapter XX); and insect pests of cereals and pulses (Chapter XXI).

Workers in temperate regions will find the last part of the book interesting because it describes a number of tropical foods which are usually unknown to investigators in areas outside the tropics. The section on food poisoning is the best summary of the natural toxins in tropical food plants that this reviewer has seen, although he questions whether it has been proven that the ackee fruit is the cause of the vomiting sickness in Jamaica.

The table of the composition of tropical foods is quite inadequate but this is not the fault of the author. It is only in very recent years that tropical foods have been analyzed intensively. It is to be expected that the large volume of data on Mexican and Central American foods published in recent years will be included in the next revision of this excellent book.

ROBERT S. HARRIS.

The Storage Life of Frozen Orange Concentrate from the Standpoint of the Consumer

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A number of questions have arisen regarding the keeping quality of frozen orange concentrate after it has been thawed in preparation for serving. The necessity for storing the thawed concentrate may occur when serving a large number of people or in the periodic administration of small quantities such as is practiced in experimental and infant feeding. Judging from inquiries received, it would appear that many consumers are uncertain as to whether the frozen concentrate should be handled in the same manner as fresh juice or as the (single strength) canned juice. The present investigations were inaugurated for the purpose of obtaining information which might serve to answer some of the consumer's questions.

In the past, most of the investigators have either concerned themselves with the keeping quality of fresh orange juice or have reported on the effects of various temperatures on the unopened cans of frozen orange concentrate but there appears to be little information available on the keeping quality of frozen orange concentrate after it has been thawed and prepared for serving.

Rohrer and Treadwell *(5)*, working with Texas oranges, reported an average loss of 3.9% ascorbic acid in fresh orange juice which was held at room temperature for 24 hours. When stored at 40° F. (4.4° C.) the loss of ascorbic acid during 24, 48, and 72 hours was 4.3, 10.8, and 18.9%, respectively. When the (single-strength) orange juice was diluted with tap water and held at 40° F. for 24 hours the loss of ascorbic acid was 4.9% compared to 3.3% in the undiluted juice.

Moore, Atkins, Wiederhold, and MacDowell *(3)* conducted similar studies with Florida oranges. The freshly extracted juice was placed in covered and uncovered glass quart jars and stored at room temperature and in the cold room (40° F.). These investigators reported that after 3 days in the cold room both covered and uncovered juices were considered good in flavor and were found to have retained 98% of the original ascorbic acid. After a week in the cold room the juices had retained 96% of the ascorbic acid and the flavor was still considered good.

At room temperature the juices could be held only 2 days. The flavor was considered good at the end of this time. At the end of 3 days, fermentation had begun. It was found, however, that 98% of the ascorbic acid had been retained even though the juice was fermented. The investigators concluded that storage of orange juice in the home is limited by loss of palatability and beginning of fermentation, rather than by appreciable ascorbic acid losses.

Experiments on shipping fresh orange juice across continental United States were reported by the U. S. Department of Agriculture *(1)* in 1949. In these tests especial care was exerted in expressing the juice and the product was rapidly cooled to 30-32° F. (—1-0° C.). Carlots of this fresh orange juice, packed in 1-gallon cans and refrigerated with ice and salt, were successfully shipped from Los Angeles, California, to New York City. It was reported that orange juice prepared by this method will retain its flavor and vitamin C content for 2 weeks or longer under refrigeration. Even after 3 weeks of refrigerated storage the product was considered superior to heat-processed canned orange juice.

A preliminary report on storage changes in frozen concentrated citrus juices was released by Moore, Huggart, and Hill *(4)* in 1950. Experimental packs of frozen orange and grapefruit concentrates were held for 6 months at —8°, 10°, 20°, 32°, and 40° F. (—22°, —12°, —7°, 0°, and 4.4° C.). The results showed no appreciable decrease in ascorbic acid in any of the samples during the period of storage. Clarification and varying degrees of gelation occurred in all samples stored at 20°, 32°, and 40° F. The rate of clarification was greater than that of gelation at the above temperatures. Gelation and clarification occurred to some extent in some of the samples stored at 10° F. and in the Duncan grapefruit concentrate which was stored at —8° F. A greater degree of gelation and clarification was observed in the concentrates prepared from seedy varieties (Pineapple orange and Duncan grapefruit). The trend in gelation and clarification was followed by slight changes in flavor. A reduction in total microbiological count was observed to occur in samples stored at all temperatures, the rate of reduction being more rapid at the higher temperatures.

DuBois and Kew *(2)* reported on the effect of holding frozen orange concentrate at 75°, 45°, 25°, 20°, 15°, 10°, 5°, 0°, —8°, and —20° F. After 11 months at 0° F. or lower no significant changes were noted in cloud retention or viscosity of the juice, and there was no etching of the can. At 5° F. the change in cloud retention was slow but definite, and changes in the appearance of the can were noticeable in 110 days. At progressively higher temperatures changes occurred progressively more quickly, according to these investigators. Stability (well-distributed pulp and cloud) could be attained by maintaining the product at a sufficiently low temperature. The authors state that it is likely that the effects of storage at elevated temperatures are cumulative and irreversible.

As the storage period progressed there was a notable reduction in the percent of living microorganisms in the concentrate at all temperatures below 25° F.

A taste panel of 20 persons failed to discriminate between portions of the samples stored at —20° F. and those held at the various higher temperatures until